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THE VISUAL APPROACH TO TEACHING

STATE INSTITUTE OF EDUCATION ★ BANIPUR ★

The Visual Approach to Teaching

T. L. Green

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PREFACE TO THE SECOND EDITION

In preparing a second edition of this book it has been possible to incorporate a certain amount of new material. The additions and alterations are mainly based on suggestions made by readers and reviewers, to whom I am grateful for their help and the reception which they gave to the first edition.

So far as possible this book has been written in the light of the needs expressed by teachers and other users, or potential users, of visual techniques in teaching and learning. The main plan emerged from the many discussions I had during a visit to India on a UNESCO mission in the early nineteen fifties. It became clear to me then that what was needed was a guide which should be comprehensive, simple and realistic. Comprehensive in the sense that it covered a wide range from practical to theoretical, simple in the sense that it did not get involved in complexities which could be avoided, and realistic in the sense that it offered ideas, methods and techniques which could be used by schools in India.

The origin and intention of the book will perhaps explain many of its characteristics, such as the lack of theory about the philosophy of education, the physiology of seeing or the psychology of learning, and the presence of practical details for a number of practical procedures often of a very simple nature. To help those who wish to follow up any particular point further references have been added. I hope that these and other additions will make the book more useful than before.

T.L.G.

University of Singapore, 1962

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I

THE VARIOUS KINDS OF VISUAL AIDS

MANY WRITERS have dealt with the classification of visual aids. Some have made it appear extremely complex and have gone to the length of inventing a special kind of terminology—others have dismissed it as of little or no importance. Instead of becoming involved in either of these extreme positions our purpose here is to offer an elementary classification of what is available, together with some guiding notes on the various forms of apparatus and methods. From general experience in teaching we know that one of the difficulties which all beginners experience in teaching is that of getting an over-all or comprehensive view. They are faced with masses of facts and are unable to reduce these to a series of basic generalizations. Those who have had experience of teaching *teachers* how to use visual aids know that teachers themselves often find it difficult to get an over-all view of the many materials and methods. This is true even in countries like England where, on the whole, schools are well equipped and teachers well qualified and trained. In other places, for example in the East, where these conditions are not yet attained, where teachers are completely unfamiliar with visual methods, and where a highly verbal approach is characteristic in all forms of teaching, it is even more likely that teachers will need help in appreciating the range and use of visual aids. It is extremely important that they should do this because they will otherwise fail to get the best out of the new methods—and this depends in the end on the teacher and not only on the lantern, diagram or film. Hence this brief treatment of the matter of classification. Once a teacher has got a clear picture of what is available and what can and cannot be done with a particular method or apparatus, then he is in a position to choose what is appropriate to his particular problem.

Classification demands the use of criteria to distinguish between items; whenever possible the criteria chosen should all be of one type or class. In attempting to classify visual aids this is not possible, except with considerable complication: in what follows the criteria adopted are simple and the whole situation can first be set out in a simple tabulation, as is shown in the following table:

A simple classification of visual aid methods and material:

REALITY AND EXPERIENCE
- *Real things:* specimens, slides, etc. in nature and in museums.
- *Direct experience:* school visits and expeditions.
- *Indirect (vicarious) experience:* dramatic reconstruction.

PICTORIAL MATERIALS
- *Representational work, 'copies', 'likenesses':*
  - original work by artist, pupil or teacher on blackboard;
  - reproductions, monochrome, colour, lithographic, etc.;
  - photographic material.

GRAPHIC MATERIALS
- *Diagnostic:* pictograph, picture graph, picture map, etc.
- *Diagrammatic:* diagrams, blackboard, textbook, wall sheets, charts, scales, graphs.
- *Symbolic:* maps.
- *Stereographic:* stereograms, to give illusion of solidity.

PLASTIC MATERIALS (three-dimensional)
- *Models:* representational, working, non-working;

scale models ;
sectional or cut-away models ;
low relief : chip carving, moulded surfaces ;
relief : contour models.

OPTICALLY PROJECTED

Still pictures : episcopic ;
diascopic : standard lantern, miniature lantern, film-strip, micro-projector
Moving pictures : 16mm film–silent–sound ;
black and white–colour.
(8mm and 9.5mm are often used in amateur non-commercial production.)
Stereo-projection : still pictures–anaglyphs and polarizers ;
moving pictures–anaglyphs and polarizers.

From this it will be seen that there are two major divisions: first, one concerned with still materials; and second, one dealing with moving materials–the film. This broad grouping is permissible, though not really exact or accurate. There are, for example, many models which exhibit movement as well as rotating charts and discs ; but this division, even if open to some objections, is convenient. Also it stresses the fact that the moving picture film is very much a medium on its own. We shall now proceed to consider the various divisions in greater detail.

Static or still materials can be used in two ways. They thus form two groups which we shall consider separately.

1. We have *static non-projected* materials which we use as they are. We look at them, handle them, hang them on the wall and are not dependent upon some kind of projection apparatus. Some of these are two-dimensional, others are three-dimensional. The former exist in one plane ; they are pictures, drawings, maps, charts and the

like. The latter, however, are solid; they exist in space, not on a plane surface—examples are a cast or plaster copy of a bone or fossil, a relief map, and so on.

Materials of a static kind have been used in education for a very long time. What teacher has not used a picture or a specimen to demonstrate his point? Our trouble has often been that we have allowed education to become too abstract, too verbal, too far removed from reality. We have, in fact, spent far too much time on words and have tended to neglect the things which are represented by our words and symbols. The new impetus towards the use of visual aids has come, very largely, from newly developed apparatus, particularly the film projector. That it should have stirred a new interest in visual aids is a good thing, but unfortunately many teachers have become more interested in the apparatus than in its purpose, in the means rather than in the ends. As a result they have continued to overlook the great potential value of other kinds of visual materials, especially those which we are now considering, the static non-projected materials.

The very fact that no form of projection apparatus is needed with these at once makes them widely available, and the fact that many of them are very simple to make means that no school need be without them. They are in fact the spearhead of the campaign to visualize the curriculum and, for that reason, every teacher should devote great care and attention to the task of understanding what they are and what they can offer as an aid to better teaching.

We are all familiar with two-dimensional static materials.: pictures in books, picture postcards, maps, wall charts, drawings on the blackboard and photographs are common in schools. The sand tray, a shallow box filled with sand, is less familiar but of considerable value. Simple diagrams can be made on a flat sand surface; it can be heaped into hills and grooved into valleys for geography; with a few bits of stick and stone we can make a model village. Better known, but still not used widely enough, are other three-dimensional aids, such as relief maps and other models. Later (see Ch. IX) information is given as to how to make these various kinds of static aid; here our purpose is to emphasize the simplicity of their nature, the ease of making and using them and their great importance as teaching devices.

Materials of this kind are however always limited in certain ways; in particular they are preferably used for individual work or for group work with small numbers of pupils. The moment one attempts to use them with larger groups difficulties arise which can be overcome only by other means: (i) by having several sets of the particular material so that several groups can work simultaneously; (ii) by making the static material on a much larger scale, so that simultaneous communal viewing is possible as with wall diagrams or wall maps; (iii) by making use of projection apparatus to give us an enlarged image for communal viewing.

2. Then we have *static projection methods* which we adopt because magnification has become an essential condition to permit communal viewing, and also perhaps because the original material is far too small even for individual observation. It should be noted that we talk here of *methods* rather than of *materials*. The latter may be extremely diverse, as will be seen in the following notes, but the methods, strictly speaking, are of two kinds only:

(i) *Episcopic projection* with the aid of an *episcope*, in which the static material is illuminated with reflected light and its image projected by a lens on to a wall or screen. The important thing is that, within certain limits, the material to be projected does not have to be specially prepared; or, even if it does, it is done by drawing or painting and not necessarily by a laborious and expensive photographic technique.

(ii) *Diascopic projection* with a diascope, better known as a 'magic lantern' or 'projection lantern'. The material, consisting of a special lantern slide, is illuminated by transmitted light which shines directly through it and, by the aid of a lens, forms an enlarged image on the screen. The image is far more brilliant than that formed by the reflected light of the episcope.

It is now necessary to consider these two forms of apparatus and their use in greater detail.

The principle of the episcope is shown in Fig. 1, which shows a vertical section through the body, with the lens and lamps in the front panel, the picture to be projected at the rear and the projected image on the screen (S). This simple arrangement has serious disadvantages, because not only is the image upside down but it is also reversed as to right and left. The vertical inversion can be corrected by placing the original object upside down as shown, where the upper edge of the picture, marked A, is at the bottom, but is projected to the top of the screen. The lateral inversion must be overcome either by using a translucent screen (see Ch. XII) or by using a mirror to form

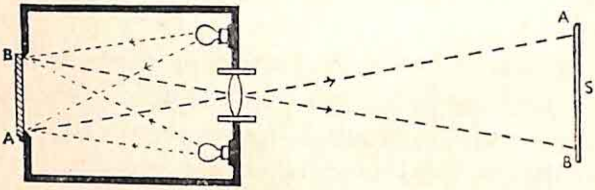

Fig. 1. Principle of the episcope.

a first image, reversed from right to left, which is again reversed by the lens. In this way print, maps, etc. are seen the right way round on the screen. Thus an episcope is constructed on the lines shown in Fig. 2. The material to be projected is placed on a flat flap or tray which is pulled by a spring (operated by a lever) until it is in contact with a glass plate which keeps it flat, and which also, if special heat-resistant glass is used, helps to keep it cool; this protects the picture, book, etc. from damage. In machines with a high-powered bulb (say, over 500

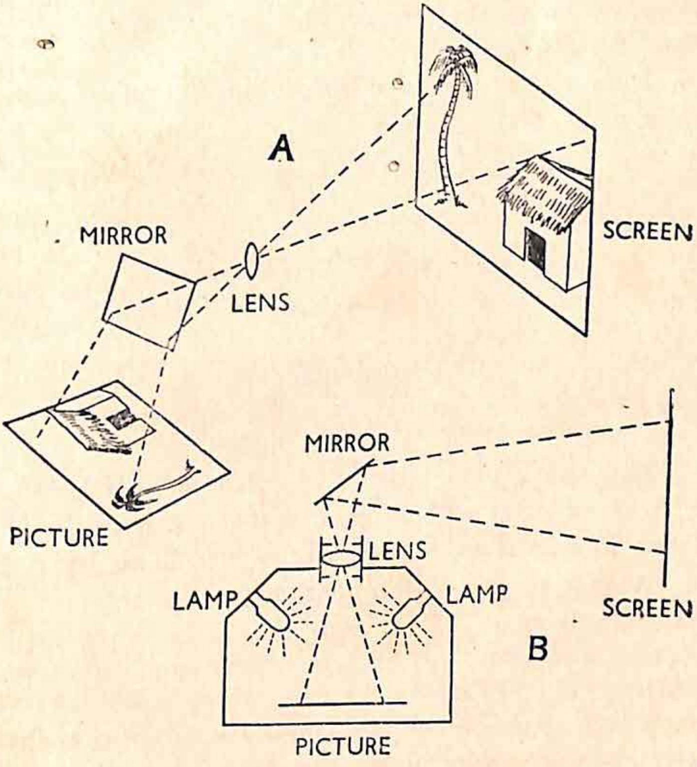

Fig. 2. Action of mirror in the episcope.

watts) the heat generated is so great that it cannot be dissipated by convection alone; therefore it is usual to have a small fan or 'blower' built into the machine for cooling purposes. In Fig. 2 (A) the mirror lies in the body of the episcope and is arranged so that light rays are reflected on it from the picture, and from it to the lens. An alternative is to place the mirror beyond the lens so that light rays passing through the lens are reflected off the mirror on to the screen. This arrangement is shown in Fig. 2 (B).

In choosing an episcope the following points should receive attention:

1. The illuminant should be as powerful as possible; if above 500 watts a blower should be looked on as essential.

2. The lamp socket should be conveniently placed and allow enough space for bulb-changing without having to dismantle the machine.

3. There should be adequate provision for adjusting the position of the lamp in three directions so that it can be centralized and put at the right height.

4. The lens should have a *focal length* appropriate to the room where it will be used so that the image is large enough for detail to be seen easily but not so large that the intensity of screen illumination is too low.

5. The diameter of the lens should be large so that it has a *wide aperture* and the maximum light-passing ability.

6. The lens should be *well corrected* in order to avoid such faults as spherical or chromatic aberration which distorts shape and alters colour values especially round the edge of the screen.

7. The focusing adjustment should be simple and

smooth-working with plenty of movement or 'travel' so that the instrument can be used both close to and far away from the screen.

8. The mirror should be sturdy and firmly mounted, and with the silver on its surface nearest the lens. A back surfaced mirror usually gives a double image, one from the glass and one from the silver layer. A top silver surface overcomes this *but it must be handled only by the edges and never rubbed.* Dust which collects on it can be removed by gentle action with a very soft brush.

9. The picture aperture should be as large as possible. A five-inch square is the most common size but in large and expensive machines it is often larger.

10. The tray or flap which carries the picture should be so mounted that it moves up and down parallel to the glass pressure plate with plenty of travel. This makes it possible to use small solid specimens as well as flat pictures.

11. The glass pressure plate should be of heat-resistant glass and arranged to slide loosely in the retaining clips. If it is too tight when cold it may fracture when expanded by heat, and in any case it is then difficult to remove it for cleaning or replacement.

12. The machine should have a tilting screw in the base for levelling.

In using an episcope in the normal manner the room must be darkened as completely as possible because a considerable amount of light is lost first in reflection off the picture and then off the wall or screen. A darkened room soon becomes uncomfortably hot, so the curtains or blinds should allow of a free circulation of air. It is often preferable to use an episcope in combination with *back* or *rear projection* (see Ch. XII) on to a translucent screen which gives a brighter image so that the room need not be so dark. Back projection, with a normal episcope, would result in lateral inversion ; it therefore cannot be used with material containing printed words. It can however be used with a home-made episcope which has no first mirror (see Fig. 1), and a design for such an instrument is described later (see Ch. XII). This is cheap and easy to make and has many advantages.

In normal use the picture, map or diagram is placed in the appropriate position and its image projected on the wall or screen. The enlarged image, focussed by turning the lens barrel, will show all details on an enlarged scale and of course in the same colours as the original. If the original is too large for the projection space it may be possible to show it bit by bit, sliding it about under the pressure plate.

It is often worth preparing episcope pictures in special form, either on a series of separate cards or on a paper or cloth strip which can be slowly pulled through the machine. Some people have even made a winding mechanism which winds the strip through. Any kind of series is more convenient to use than a dozen books in which the pictures are scattered about ; such a series can be traced from books, pasted on cards and painted in suitable colours.

Small solid objects can be used; such as fossils or bones, but only one plane will be in focus at a time. Therefore one must use differential focusing, taking the object plane by plane, as it were. Many teachers seem never to think of using an episcope in this way, yet it is most valuable.

One can also use the episcope for demonstrating certain kinds of movement or process. An example is in teaching the use of the slide-rule. Each pupil has a rule and the teacher uses his for projection on the screen. The movements and settings can then be explained, demonstrated and accurately followed by each pupil. Small dissections, patterns, mechanisms and so on can also be shown in this way in order that a series of changes can be seen by all.

The enthusiastic teacher will make models of a kind which can be used with the episcope (see Ch. XI). Thus functional models of a 4-stroke engine and other such actions can be made with plywood on a base of suitable size and demonstrated to the whole class simultaneously. Some teachers have even developed ways of demonstrating chemical experiments on a micro-scale with an episcope—a trick of great value when dealing with a colour change in an indicator, for example.

Although it is possible to treat living specimens as models (thus demonstrating locomotory or respiratory movements for example), it is not normal for them to live in such intense light nor at such high temperatures. If they are so used it must be for very short periods and with every precaution to avoid distress or damage.

The episcope is an admirable apparatus for making enlarged copies. An image of, say, a map is projected on to a sheet of paper and all the detail can rapidly be copied by tracing the lines with coloured pencils. The enlargement can be to any desired degree and one can take originals on different scales and bring them to the same enlarged scale. Episcope projection also allows of superimposition of detail from different sources. In these ways a series of wall maps or other such things can be prepared cheaply, easily, quickly and accurately. For most purposes the finished maps or drawings will be about 30″ × 20″ (75 × 50cm) so that the paper (which is pinned to the wall for drawing on) will be not far from the episcope lens. It may be found that the lens will not focus as closely as this. Should this be so, or should the image be in focus but too large, pull the platform down from the pressure plate and use a second sheet of ordinary glass to keep the original flat. This has the effect of increasing the distance between the object and the lens so that the image is formed nearer the lens.

The principle of the diascope is shown in Fig. 3. The

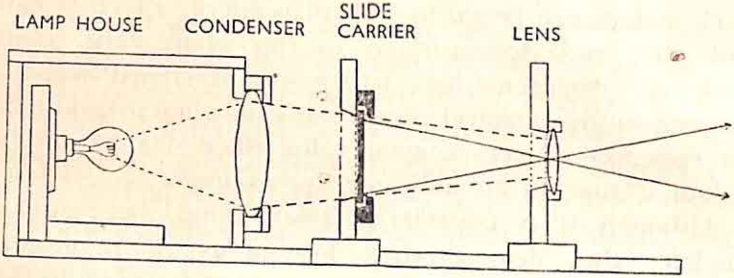

Fig. 3. Principle of the diascope.

object consists of a lantern slide. This is illuminated by a high-powered bulb in combination with a condenser, and its image thrown on the screen by the lens. Because the light is transmitted directly through the slide, the screen illumination is far brighter than in the case of the episcope when bulbs of the same wattage are used. It is usual to use a blower with lamps of over 250 watts, but efficient projection is possible with lamps of 100 or even 60 watts.

In buying a projection lantern note the following points :

1. Standard lantern slides (British standards) are $3\frac{1}{4}''$ (82mm) square.

2. The carrier, which is used for changing the slides, should be simple and sturdy, and 'gadgets' aiming at

automatic changing are best avoided. In any case they add to the cost.

3. A lamp of 100 or 150 watts of special projection type should be used. Acetylene is a standby, the 'limelight' and 'carbon-arc' are outdated, though new micro-carbons in glass envelopes may yet have a future.

4. The lamp must be adjustable in all directions and easy to get at.

5. The condenser lenses must be easily removable for cleaning.

6. The projection lens must be of wide aperture and a suitable focal length, well corrected and with a suitable focusing movement.

7. The lantern should be well made and well ventilated and fitted with a tilting device.

It is possible to make a projection lantern but, for various reasons which are dealt with below (page 15), it may be preferable to make a miniature lantern rather than a standard lantern. A simple design for the former is given later.

In using a projection lantern one is dependent upon lantern slides. These are positive photographic transparencies : in other words, pictures made with silver salts in a gelatine medium which is coated on a sheet of glass. We look *at* prints, but we look *through* lantern-slide transparencies. In fact we project their image on a screen and look at the image. For protective purposes each slide has a cover glass laid on the gelatine of the positive and the two are bound together with a tape round the edges. To achieve a finished and neat appearance a mask of black paper is used as a frame round the picture. To ensure that the image appears the right way up on the screen the slide is *spotted*. That is, it is marked with two white dots which show which is the top of the slide when it is looked at with the picture and printing in the correct position. To deal with inversion the slide is *put in the carrier the wrong way up and the wrong way round*: that is, the spots must be towards the bottom of the carrier and facing the screen. Each slide should carry a white strip on its top edge for writing a label which will then be visible when the slides are stacked in a storage box.

Lantern slides are purchased ready-made, or in schools where funds and facilities are available they can be made easily and fairly cheaply. Brief details of the process are given in Chapter XIII. It is however not essential to rely upon photographic slides only. For many teaching purposes, especially in connexion with temporary demonstration work, permanent photographs are not required and one can do with simpler materials. A few of these are described below:

1. 'Glass ink', usually white or black, can be used for making diagrams on cover glasses which can be used as they are as slides.

2. 'Glass crayons' can be used with the added advantage that several colours are available.

3. Lamp-black slides are made by smoking a cover glass on one side and then drawing a diagram on the smoked surface with a pin or fine pen point. It can be used *carefully* as it is or protected by a cover glass.

4. Cellophane slides are useful where it is desired to make use of printed words or figures or both, as for example in a table of commercial products or population changes. Cut a piece of cellophane $3\frac{1}{4}''$ (82mm) square, lay it *on the carbon surface* of a typewriter carbon, place in the machine and type in the necessary material, being careful to leave a $\frac{1}{4}''$ (6mm) margin for binding. Take the

cellophane and sandwich between two cover glasses either temporarily or as a permanent mount. Diagrams can be drawn on cellophane using carbon paper and a top sheet of thin paper.

5. Cellophane can be used for tracing diagrams, where there is much detail and great exactness is required, if glass ink is used. Indian ink does not flow very evenly on it. The cellophane is sandwiched between glass.

6. Indian ink can be used for drawing direct on to glass if a drop or two of saponin is added to reduce surface tension—any 'wetting agent' can be used.

7. Thin good-quality tracing-paper, tracing-linen or even tissue paper can be used for diagrams and then sandwiched as a slide between cover glasses.

The miniature lantern is so much a part of school apparatus today that we must devote some attention to it. Those used today are the direct outcome of the production of the Leica camera by the firm of Ernst Leitz of Wetzlar, Germany. This camera was originally designed for testing lenses for the cinema industry in 1911 by Oscar Barnack. In 1925 it was put on the market in Europe and brought about a revolution in photography.

The Leica uses cinematograph film which is 35mm wide. On this a negative 36 × 24mm is produced (see Fig. 4), which is used to give a paper print by enlargement. The Leitz Company, however, also saw that here was an excellent way of producing small lantern slides. The negative was copied on to another piece of film to give a positive transparency and the film mounted between two pieces of glass to protect it from scratching.

These miniature slides, which today are standardized at 2″ × 2″ (50 × 50mm), have a number of advantages over the standard slide:

1. They are relatively cheaper to make.
2. They are lighter.

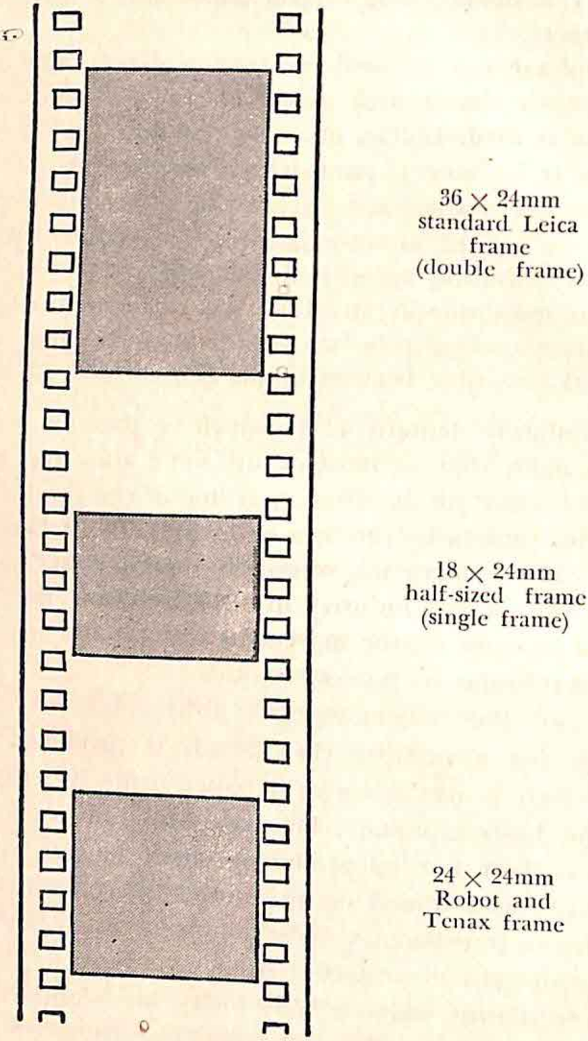

Fig. 4. Frame sizes on 35mm film.

3. They take up relatively less space than an equal number of standard slides.

4. They are less likely to crack if accidentally dropped.

5. The cost can be further reduced by using cardboard glassless mounts.

The Leitz Company, however, also made provision for copying a long strip of negatives on to a long strip of film to give a set of positive pictures. Today we call this a filmstrip. The pictures can be printed on the strip in three ways, all with one dimension of 24mm. The relative arrangements are shown in Fig. 4. For amateur production the original size (36 × 24mm) is the most suitable; this is the full frame or 'double' frame picture shown at the top in Fig. 4. The square shape of 24 × 24mm is used in a few cameras, such as Robot and Tenax. The smallest of the three, the single frame, is half of the double frame, i.e. 24 × 18mm; it is the size most used by professional producers. The great advantages of the filmstrip are:

1. It is unbreakable.
2. It rolls up and occupies little space.
3. It is relatively cheap.
4. It is very light.

It has two disadvantages however:

1. The pictures are arranged in a fixed order which can only be changed by cutting the strip or moving it about a good deal in the projector.

2. It can easily get scratched or have the sprocket holes damaged.

It will be shown later that teachers who have a little manual skill can make filmstrips and projectors for themselves by quite simple means.

An interesting form of diascope projection, which has been used for a long time and is now coming back into favour, is *over the shoulder* projection. The apparatus merely consists of a projection lantern with its optical axis arranged vertically and with a silver surfaced mirror

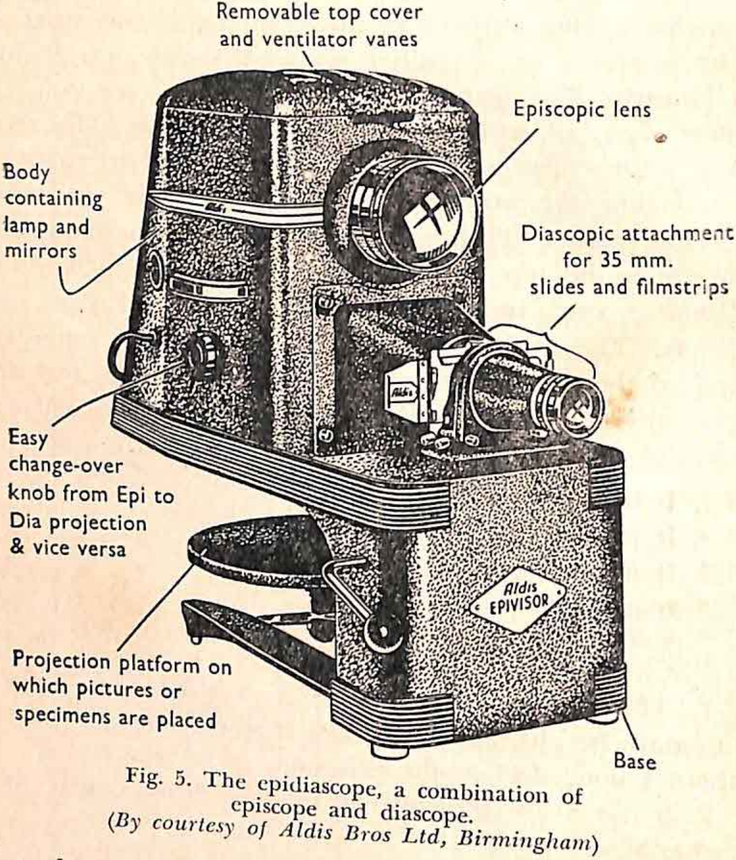
Removable top cover and ventilator vanes
Episcopic lens
Body containing lamp and mirrors
Diascopic attachment for 35 mm. slides and filmstrips
Easy change-over knob from Epi to Dia projection & vice versa
Projection platform on which pictures or specimens are placed
Base
Aldis EPIVISOR

Fig. 5. The epidiascope, a combination of episcope and diascope.
(*By courtesy of Aldis Bros Ltd, Birmingham*)

just above the lens. The mirror reflects the light rays through 90° and so projects them on to the screen. With such a lantern on the demonstration bench and the screen on the wall behind him the teacher need not leave his position and can point to details on the screen which is conveniently placed in front of the class. Instead of having the usual carrier for slides this kind of apparatus has a square plate of glass on which slides are laid in a horizontal position. It is convenient to have this glass plate bigger than the standard slide. This makes it easier to use as a base for drawing or writing on a sheet of tracing-paper or translucent plastic which is laid on the glass plate. In this way one can draw in black and white or colours while projecting and the class can see the drawing being built up stage by stage on the screen. It will also be found that using a needle stuck into a penholder as a pointer on the transparency is more convenient than pointing with a long stick at details in the screen image.

The epidiascope is a combination of episcope and diascope. As such it may be used with opaque pictures as well as transparencies. In a few cases a single lens is used for both methods of projection, but the majority of instruments make use of two lenses. Also, in some cases, it is possible to use both standard and miniature lantern slides and filmstrips in the episcope and even add an attachment for micro-projection with microscope slides. This degree of versatility makes the epidiascope valuable where it is desired to have but a single instrument possessed of several functions.

The micro-projector is another special form of diascope projection apparatus which is chiefly of interest to biology teachers. The principle of operation is that of the diascope, but the focal lengths and diameters of the optical elements and the area covered are all smaller than in other diascopes. This apparatus is in fact made to deal with microscope slides instead of with lantern slides, and it can be considered as a microscope in which a real image is examined after projection on a screen instead of a virtual image formed in space. The general layout of a typical micro-projector is shown in Fig. 6, from which it is seen that the various parts are arranged to move

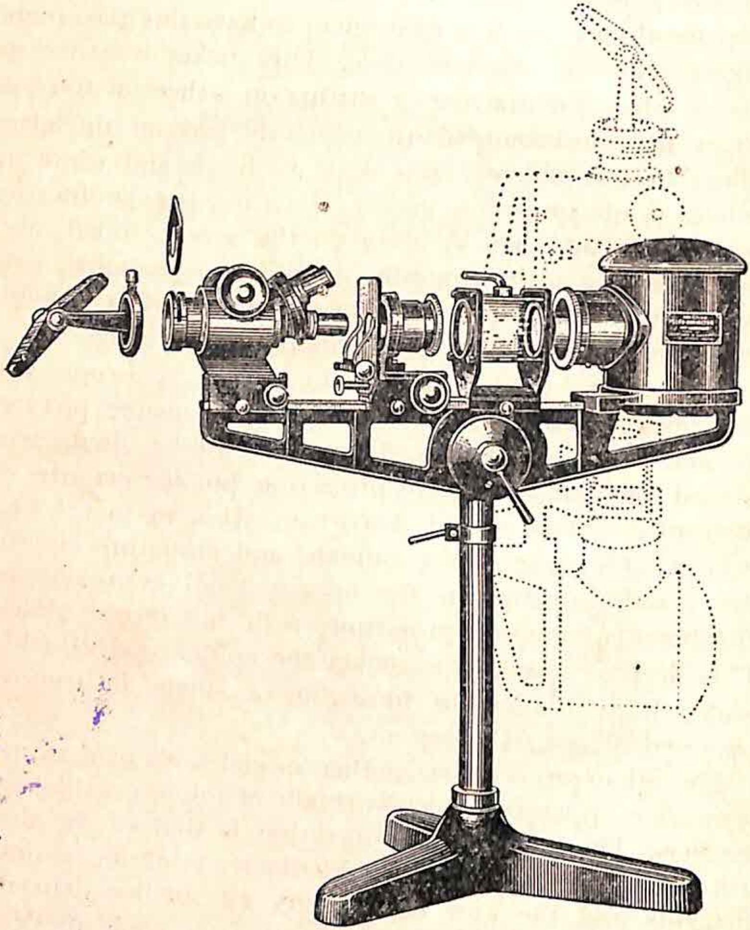

Fig. 6. Design of a typical micro-projector which can be used either vertically or horizontally.
(*By courtesy of Flatters and Garnett Ltd, Manchester*)

and clamp on a basal slide which can be rotated through 90° to give vertical projection.

Vertical projection is useful in two ways. If the micro-projector is placed on the floor below a bench or table which has as its top a square of glass, it can be used in a darkened room as a drawing device. A sheet of tracing-paper is laid on the glass plate and the image drawn in with pencil. Vertical projection can also be used in connexion with the study of aquatic organisms which are in a Petrie dish of water in the position normally occupied by the slide.

For projection with living organisms it is however often more convenient to have the axis horizontal and to have a trough of water in the system for cooling purposes.

In schools which possess microscopes (even quite simple ones) and where funds do not permit of the buying of a micro-projector it is possible to make one by using a microscope. Arrange the microscope horizontally and, with the aid of an intense light and a condenser lens, project an image through the tube, without the eyepiece, on a small screen. If the microscope is vertical use a mirror to turn the rays through 90°. If the eyepiece is left in place, put a small prism, with the sloping surface silvered, over the eyepiece and project on a vertical screen. Fig. 7 shows vertical projection.

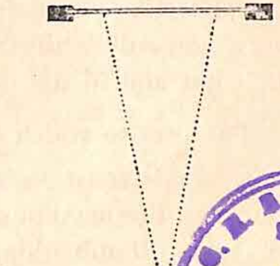

Fig. 7. Using a microscope for projection on a translucent screen viewed from above.

Anyone handy with tools can make a small micro-

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projector. As a lamp use a projection bulb from a 9·5mm or 16mm cine-projector and for a lens use a magnifying glass from a pocket magnifier.

In purchasing a micro-projector pay attention to the following points :

1. Sturdy construction to give stability and rigidity.

2. The use of standard R.M.S. threads so that ordinary microscope objectives can be used as lenses.

3. Ability to rotate between horizontal and vertical position.

4. Provision of a water cooling trough.

5. Adequate accuracy of construction allowing sufficient sliding of the components.

6. Effective means for centralizing the lamp and optical axis, not only while the machine is cold, but also while it is hot and in use.

The uses to which the micro-projector can be put are :

1. *To demonstrate to the class as a whole.* In this case one uses the maximum magnification even at the expense of some illumination. (After pointing out the various features, get the pupils to make a quick sketch from the projected image, showing the general layout.) It is usually found that this large-scale magnification is only suitable for dealing with the larger cell masses and tissues, rather than the more minute detail of single cells, etc.

2. *To demonstrate to individuals or a small group.* Here a smaller image and hence greater intensity of illumination is used so that much more detail can be observed. This makes the micro-projector superior, in some ways, to the demonstration eyepiece with its pointer because this can only be viewed by two people at the same time.

The Projection of Moving Pictures

The cinematograph has been the topic of so much writing, is so potent a device in its social effects and involves so many technical problems, that to attempt to deal with it as a part of but one chapter might well be questioned as impossible. It is however important, both here at this point, and continuously when thinking of visual aids, clearly to appreciate the educational aspect of the problem. Visual aids are means to an end; they are not, or should not be from the teacher's viewpoint, ends in themselves. It is true that some knowledge of mechanism and technique is required to get the best from the moving picture projector; but the real values the teacher seeks, the educational ends he has in mind, are to be thought of in terms of teaching and learning, in the extension of understanding and the change of attitudes. Our discussion, therefore, while it must include an elementary technical treatment here, must be thought of in wider terms which are dealt with in later chapters.

Moving picture projection is carried out with films of five widths:

1. 35mm, the standard film of the entertainment world, in which each frame or picture is 24 × 18mm in silent film. In sound films, which have a sound-track which has to be included between the sprocket holes, the 24mm is reduced. Although many educational and documentary films are made (or 'shot') on 35mm film, this size is not used for teaching purposes.

2. 16mm, the universally accepted size for educational purposes. Silent films have sprocket holes at both edges of the film, but in sound films one series is left out and the space occupied by the sound-track.

3. 9·5mm, the film size originally introduced for

amateur cine-photography and still widely used today.

4. 17·5mm, an aberrant size introduced as a basis for sound films by Pathescope Ltd, the originators of the amateur cine-camera.

5. 8mm, a 'micro-size' introduced to reduce the costs of amateur film-making.

The universal acceptance of 16mm film for educational purposes makes it unnecessary to enter into further discussion of this aspect, except for a few points. In planning film-making for special purposes, as for example by a local education authority in England or a state education department in India, conditions sometimes preclude the use of a commercial producing unit and necessitate 'doing the job oneself'. In the subsequent discussions the relative costs of the film are often taken as a reason for using the 16mm rather than 35mm film. To the writer, this argument appears erroneous. The cost of the raw film is not a major item. Apparatus, other materials and wages will be the biggest items. It is true that excellent 16mm cameras and lenses are available and that they are lighter and less bulky than those for 35mm work; but the costs, especially in the second-hand market, are not greatly different. What is important is the processing of the film. Results of a high quality can be produced on 16mm film but, despite the many advances in this field, the services available for 35mm are far superior.

Having shot the film on 35mm it can be printed by optical reduction on 16mm for showing. Thus one enjoys the technical advantages of 35mm camera work and the universality and reduced costs of 16mm projection.

Recently there have been many technical advances in all aspects of photography. So far as cine-photography is concerned the improvements in lenses, mechanisms and film materials have been so great that there is now a real possibility for 8mm to supercede 16mm in the educational world. And the very recent improvement of sound film in 8mm brings this possibility very near indeed.

If this takes place purchase, production and projection will all be cheaper, and yet of high standard. Moreover this will make it possible for more schools to use moving-picture film and even make their own films. If school production is restricted to 8mm silent black-and-white film, and if a simple Japanese movie camera is used, costs can be very low and production quite satisfactory. While this subject will not be pursued further, it may be useful to mention a few points to which attention should be given by those about to purchase an 8mm camera.

1. While a zoom lens may be cheaper than a set of say three lenses, each of different focus, it may be less highly corrected and, in cases where there is no interchangeability, close-ups may be difficult or even impossible to take.
2. Reflex focus and viewing is to be preferred whenever accurate framing is needed, as in close-up work or telephotography.
3. Fixed-focus cameras are not suited to close-up work.
4. Coupled automatic exposure meters, however convenient, are less efficient than a first-class separate meter.
5. Coupled meters often limit the user to a narrow range of film sensitivity.

Another important point concerns the type of film to be used. In amateur still photography most people are aware of the processes whereby they make a negative first and then have a print made on paper—this is a positive. The negative they keep and from it any number of positive prints can subsequently be made. In amateur cine-photography, because of the need to reduce costs, use is made of 'reversal film' which, after exposure, is developed as a negative and chemically reversed to give a positive print which is a transparency on celluloid instead of a picture on an opaque paper base. The disadvantage to this is that only one copy is available and this wears out, as the useful life of most films is from fifty to seventy showings.

In making an educational film it is a wise economy to use negative stock at the start and keep this negative with care. A positive print can be made and used in the editing and cutting of the film until an acceptable final version is made. When this is finished the negative is cut to match and a series of prints at once made for circulation ; the negative is kept safely in store.

These points are of interest only to those who intend making film on a fairly large scale. Our concern in this book however is rather with the teacher as a user of the film and it is to his problems we now turn, though the treatment even of his problems will be brief. Even where educational provisions are considerable the film is not used in every school because of the cost involved. In India and Ceylon the possibility of using the film is even more restricted, and for the same reason. Our emphasis must therefore be on other visual media.

Projection Apparatus

Many excellent machines are marketed about which full information is available from dealers. In deciding which to buy, apart from the question of cost, the following points should be kept in mind :

1. Sturdy construction, especially of moving parts.
2. Ease of manipulation and access to parts ; one does

not want to have to dismantle the machine to adjust one item—especially when hot.

3. Quiet running.
4. Simple threading and an easily operated gate mechanism.
5. Ability to take large spools.
6. Quick mechanical rewind.
7. Availability of service and spares.
8. Portability.

From brochures and catalogues many other points will be seen. Every dealer is certain that his machine has all the good points and none of the bad ones. The wise buyer sees several types in action and talks to those who have used them before deciding on any particular make.

16mm projection machines can be conveniently looked on as of three types:

1. Those for *silent* films only. These are cheaper, but limited in their value to the teacher. They cannot be used for sound films because the double sprockets will tear the film.
2. Those for *sound* films. These machines can be used also with silent film and must have two speeds, 16 and 24 frames per second, for silent and sound films respectively.
3. *Multi-size projectors* which will project from films of several widths. Details can be obtained from dealers.

Types of Educational Film

The earliest films were silent and black and white. In silent films the logical continuity of meaning is preserved by the picture sequence and by the use of sub-titles and explanatory notes which are projected on the screen as part of the film. With the appearance of 16mm sound films, the use of sub-titles was given up in most cases and explanation made part of the commentary. There are occasions when sound is essential if full realism is to be obtained, as in the recording of 'natural sound' such as bird-song and human speech. It is however certain that many subjects are treated as sound films which could be as well done on silent film at less cost to producer and teacher. Good as sound films are it must not be forgotten that a silent film gives the teacher a better chance of making his own commentary while the film is showing. 'Mute' films are the result of leaving the sound-track off what was made as a sound film. In most cases they are not very satisfactory because of the lack of sub-titles.

The appearance of colour was a further step towards realism. It often has very great value—for example in nature films—but it adds very greatly to the cost of film-making and renting and is now often used when it is not essential. Not all will agree with this—but black and white is no more misleading than some of the colour processes which are very far from nature.

In general it may be said that while sound and colour are of great value, they are not always essential and that much excellent work can be done with silent black-and-white films. When we turn from the physical aspects of film to consider it in functional terms, it will again be seen that simplicity is not only cheaper but has other values for the teacher, and it is the teaching value of a film which counts.

The standard unit in 16mm film production is the 400-foot reel which runs for about ten minutes at sound speed and eleven minutes at silent speed. Within these limits many excellent films have been made which adequately cover topics of considerable extent. These are, however, what we may call 'smaller topics' which can be dealt with in a film lasting only two or three minutes. The larger commercial producers have not looked on these with favour.

A more important aspect of classification is concerned with the functional use of the film. Thus some films can be looked upon as introductory, their function being to give an orientation on which new studies can be built. Others, usually used at a later stage, are direct teaching films which aim not so much at a general as a specific viewpoint. Some people refer to these two types as background and foreground films.

An extremely useful type is the 'cyclic' or 'loop' film, which is an endless loop which runs continuously through the machine. This is arranged with the aid of a 'loop absorber' instead of two spools as generally used. For demonstrating cyclic action (such as the working of a petrol engine) or for repeating a single event (such as a diver taking off from a springboard) this is very valuable. A loop absorber consists of a vertical pillar with two arms, one above the other, at right angles to the pillar. Each arm carries a number of pulley wheels 16mm wide. The film is threaded through the 'gate' of the projector and then, as it forms a loop or circle which cannot be fed from one spool to another, it is laced over the series of pulleys. It can then be run continuously over the pulleys and through the gate for as long as is required. Fig. 8 shows the principle of the apparatus. The normal course of the film through the gate (G) is shown by a continuous black line. To project a loop the film is threaded through the gate in the normal way, but instead of being passed from one spool to another it is distributed as a continuous loop over the series of small pulleys of the loop absorber. These pulleys are shown as small circles, the normal spools as large black circles.

While the majority of loop absorbing mechanisms work on the principle described above and illustrated in Fig. 8, new methods are now appearing. Perhaps the most interesting of these makes its appeal because:

1. The film loop is contained inside a plastic cover which acts as a protective cassette or cartridge.

2. The cartridge is loaded direct into the projector by pressing it into a slot—just as a cartridge clip is loaded into a rifle. This reduces the loading time and the risk of damage as no threading is involved.

3. The system is based on 8mm film.

4. The projector is small, compact, light, easy to operate, and provided with efficient cooling and illumination and

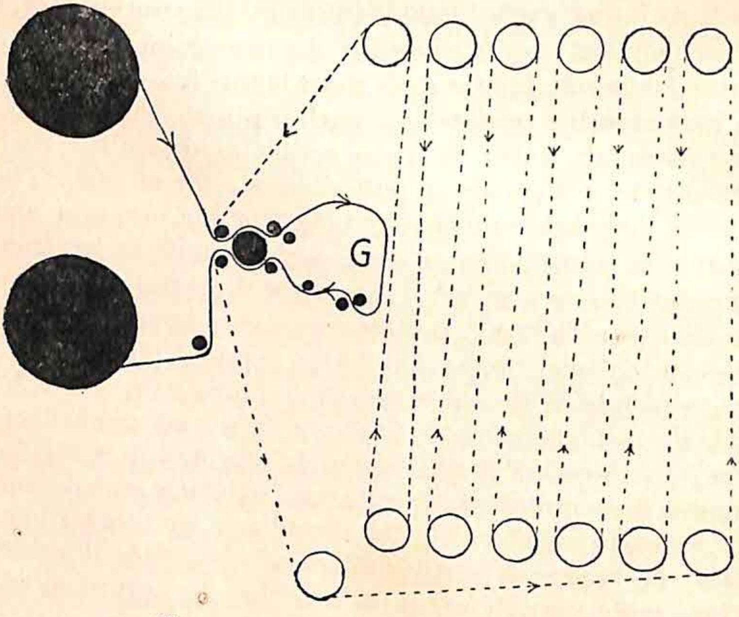

Fig. 8. Principle of the loop absorber.

a lens of f1.5 aperture. (Silent film only can be used.)

5. The cost is comparatively low.

6. The company (see appendix) can provide a packaging service to mount suitable films provided by customers as loops.

It is also convenient to notice here another basis of division into ' natural ' films and ' diagram ' films. Natural films are straight photographic records of actual events, places or things. Diagram films are film records of specially prepared diagrams which aim at simplifying and explaining a complicated structure or process. The diagrams we use in our textbooks are static. We can use the same type with the film and project a stationary image on the screen. Far more valuable however is the moving diagram, in which the various lines and parts move on the screen. This is achieved by ' animation ', a process in which the sequence of movements is photographed by a long series of single exposures with a slight movement between each. The cumulative effect produces movement on the screen. Some films include both natural photography and animation, but there are also films based completely on animation.

II

PROBLEMS IN LEARNING AND TEACHING WHICH CAN BE APPROACHED BY VISUAL MEANS

THE CHARACTERISTIC PATTERN of school life is that of the classroom where a teacher is involved in teaching a group of pupils. It is on this pattern that most of our educational theorizing has centred, and it is because of this concern with the group that we have so often tended to overlook the individual. Moreover we have often tended to neglect the teaching of *pupils* because we have become absorbed in theories about the teaching of *subjects*–we have set out to teach maths, instead of a boy or girl! We have indeed made difficulties for ourselves in other ways, especially because we have tended to seek a method of teaching without giving sufficient thought to methods of learning. Whenever a particular method of teaching is put forward we are reminded by the critics that no two teachers ever teach in the same way; but much less often do we remember that no two pupils learn in the same way. Still less often do we take into account another point of importance, that in the end all learning is a purely individual phenomenon. We can teach others, but we cannot learn for them. Learning is an individual experience, an activity taking place in a private mental world. To that world we have no direct access, yet what goes on in that world is, very largely, a reflection of the relationship between the minds of teacher and taught. On the quality of that relationship much of the success of teaching, and even more of learning, depends.

Such an argument emphasizes the importance of the approach to the individual, and there are many people who are therefore ready to condemn the visual approach to teaching because it appears to be a group approach. This it certainly is, but at the same time it offers many avenues for an individual approach. In fact it is the general experience of those best qualified to make judgements that the visual approach has one very important value. It challenges the teacher to conscious and critical thought about the approach to teaching at almost every moment. The use of visual aids is not a passive experience : they demand the active participation of the teacher in the process from the beginning. In this fact lies one of their chief values ; they improve learning in direct proportion to the extent that they improve teaching. And they improve teaching only to the extent that the teacher critically examines the problems involved in learning and teaching. It is to a brief examination of some of these problems that we now turn.

One of the most obvious values to be derived from the use of visual aids is opportunity to see both individually and communally. American textbooks for school use tend to be lavishly illustrated. English books, though often well illustrated, are not so fully pictorial as those of America. Here in the East it can be said that, on the whole, our school-books are very poorly illustrated, both as regards quality and quantity of illustration. Our pupils, often coming from a limited background and with very little experience, have to rely upon verbal presentation. They are limited both by their experience and by their linguistic ability and are frequently led to form erroneous concepts. It requires only the slightest exploration to find that a combination of inadequate book illustrations and lack of experience on the part of the pupil (and often of the teacher also) has resulted in concepts which are ill-defined and misleading. In some circumstances even a competent teacher would be hard pressed to give a purely verbal description of a complicated structure or process, yet many of our pupils have nothing else on which to rely.

If the new awakening in visual education had done nothing else it could still claim today a great contribution to teaching and learning. Our 'visualized' curriculum makes a wider appeal and offers a richer experience of greater interest than any which have preceded it. On film and filmstrip there is available a wealth of material and, where cost makes this inaccessible, there is much to be obtained from the pages of out-dated pictorial magazines and newspapers. Finally—because in the East even these are beyond the economic reach of many schools—the blackboard and even the sandy surface of the ground can be used with effect. Finance indeed is a big factor, but behind everything lies the attitude of the teacher.

By making use of visual aids at whatever level he is able, the teacher can ensure that his pupils do *see*—perhaps for the first time—even in relation to simple things. It has been said in an old adage that 'seeing is believing'. This we need not stop to examine ; but what we must note is that seeing may often be the first step towards understanding. It is because they have not been able to take this first step that so much of our pupils' learning is done in terms of remembering instead of understanding. Inadequate maps, diagrams which are too small, tabulations which are too greatly simplified, time-scales which leave empty many of the world's greatest ages, pictures slavishly copied from one textbook to another by writers who have never learned that time marches on—these are the brakes on learning.

By simple methods, described in practical terms in other chapters, and at very small cost, education can be given greater meaning if we ensure that our pupils can *see*. If we have no projection apparatus, let us use scrap-books and postcards; if we have no microscopes, let us use the simplest of hand lenses–in some way let us exploit the first step in learning. For those who have projection apparatus, of whatever kind, there is open the further opportunity of *communal seeing*. The projected picture, because of its large size, its bright illumination and its novelty, commands interest. The teacher can assure himself that all his pupils can see and he can, using the large-sized image, discuss points of detail with the class as a whole. Thus communal seeing permits class teaching and, where visual demonstration of some kind is essential, it leads to a saving of time. This is perhaps best seen in relation to studies of microscopic material. Individual examination is time-consuming where only one or a few instruments are available, and usually cost prevents provision of more miscroscopes. A single micro-projector does much to overcome these handicaps. It must, however, be admitted that the projected image cannot yield the detailed results which can be gained by individual study. Nor must it be forgotten that time devoted to preparing and setting up the projection apparatus is easily lost from the teaching situation and that the darkening of the room is not always conducive to learning and concentration. It is shown elsewhere (see Ch. XII) how the latter problem can be avoided by the use of back projection either with or without a mirror.

In relation to the problems of size, various modes of visual presentation can be used and it will be seen that their value lies in either enlargement or reduction as compared with the original. With the aid of a magnifying system, whether it is a simple hand lens or a compound microscope, we can examine detail which lies beyond the limits of unaided vision. At the other extreme we can deal with objects of large—even vast—size by diagrams, photographs or models on a reduced scale. This ability to deal with the problems of size, which we may term control of scale, is of great value and has for long been recognized. A point, however, which is often overlooked is concerned with the pupils' reaction to control of scale. He does not possess the experience of the teacher and hence his opportunity for cross-reference is reduced. An air photograph of the Pyramids or of the Empire State Building in New York can only be appreciated against some terms of reference. The first step is, of course, verbal. The visual experience gained from a picture must be enriched by discussion, by analogy and by comparison with what the child already knows. A very obvious way of doing this is by giving measurements, but one must remember that children's ability to visualize large values is limited ; after a certain limiting value they are no longer capable of discrimination. For a rural child, who has perhaps seen a few two-storied houses, to speak of skyscrapers with forty floors is probably largely meaningless. Even to use precise units and say it is three hundred feet or five hundred feet high may give no impression beyond a feeling that it is 'very high'. In situations of this kind an idea of scale can be obtained if the original picture includes, for example, motor cars or human figures. In other cases one must seek analogies with the common objects of everyday experience, and in doing so it must be remembered that they must be common for the child, not the teacher.

As teachers, we find that the things we study not only present us with problems of size but also of location. Of the two examples mentioned earlier one is in Egypt, the other in New York. For the vast majority of children both are inaccessible, and even those who live at the foot of the one are unlikely to see the other. In this situation we again see one of the marked values of visual aids, for they offer us a way of overcoming the problem of location, just as the aeroplane has reduced distance problems for the traveller. Photography, whether it be applied to making prints on paper, to filmstrips or to moving picture films, has given us a means of dealing with the factor of space. Neither we nor our pupils can travel the world, but we can bring the world to the classroom on the screen. Moreover, as we know from experience, the illusion of reality can reach a high degree of fidelity. The various factors which contribute to that are discussed in the next chapter. Having mentioned the point here, we merely need to consider how greatly the teaching of geography, history, the social studies, biology and other subjects could be enriched by calling in the use of visual aid materials. Realizing how little use has been made of these aids one may well wonder how it is that our pupils have acquired real understanding of anything which lies outside their immediate experience.

In connexion with the time-scale we again find in visual aids a valuable ally. With model, chart and diagram we can reconstruct the past and so look backwards into history. But it must be done carefully, otherwise the artificialities become painfully obvious. The intention should be to give some feeling for the past rather than to give too detailed a picture. It must also be realized that a pupil may have a fairly considerable knowledge of details but yet have no generalized conceptions ; in particular he may lack any sense of a time-scale. For psychological reasons we cannot give to the immature mind an adult appreciation of time sequence ; we can, however, by appropriate choice, do much to help in this situation. Time-scales and charts, which are discussed in more detail later, are an obvious step. In discussing visual contributions to the sense of time we must notice the efficiency with which the newsreel and 'camera-observer' have built up, on many occasions, the illusion of the present—of being there as a spectator on the spot. Into the mechanics of this we need not go; the point is that the 'eye witness account' has a considerable value as a teaching device.

A third aspect of control over the time-scale is seen in connexion with time-and-distance relations in which the problem is presented to the teacher in terms of velocity of movement. The beating movement of cilia, the wing action of a flying bird, the motions of a machine, these and many other processes proceed at rates which make normal visual observation impossible. At the other extreme we have movements and processes of extreme slowness: the growth of a plant, the abrasive action of a river and the like. In both cases, visual aids, especially the motion picture camera, can come to our aid, because with it we can slow down the one and speed up the other—at least on the screen.

There are thus three fields in which visual aids offer to the teacher valuable help, help which comes from those special characteristics of visual devices whereby control can be exerted over scalar, temporal and spatial perspective. In these three cases the special difficulties which have to be overcome—scale, time and space—are clear-cut and definite, and the contribution towards overcoming them through visual aids depends upon equally clearly defined characteristics of the visual medium. It will be seen from what follows that there are other problems of learning and teaching which are less rigidly defined, but to which the visual approach makes a useful though perhaps less definite contribution.

In the compass of a single lesson it is frequently necessary to use materials of widely different kinds, often from many different places, and sometimes not always available at the moment when they are wanted. A single history lesson may call for maps, photographs, models, printed and other documentary evidence. The result is all too familiar : the pupils hear of or read about these things and, if they are particularly fortunate, they may see illustrations of a few of them. Cost alone will prevent them from ever seeing many of these materials if they have to be assembled by separate teachers ; nor must the drain on energy and time be overlooked. Maps, models and so on have either to be bought or made for the purpose.

Here it is that the various visual media, above all perhaps the filmstrip, can prove so valuable. Maps, models, photographs, charts and documentary evidence, however variable in size and type, can be presented by filmstrip. Providing the cost can be met, and this is far below that of the original materials in most cases, the teacher can have at his command exactly what he wants precisely when he wants it. He is relieved of the task of making the materials himself, he becomes independent of seasonal or other periodic factors, he has no difficulties of storage and preservation to contend with and he is thus enabled to devote his attention to teaching, instead of to preparations for teaching. For those unable to make use of filmstrips—and in the East there are very many who cannot—use must be made of illustrative materials collected in scrapbook or other form. The point is that in some way the teacher can have, readily and always available, materials which reflect great variety.

In subjects which have a structural basis, difficulties begin to arise as soon as the structures become at all complex. For those whose ability to deal with form-relations is low, these difficulties become important at low levels of complexity. Difficulties of this kind arise in the study of plant and animal structure, in elementary physical geography, in the manual arts (such as woodwork and metalwork) and other subjects of this type. If the situation is examined it is usually found that the basis of the difficulty lies in the inability to interpret two-dimensioned pictures in three-dimensional terms. Related to this is the difficulty of appreciating internal structures from external appearance. In this field of three-dimensional relations, visual aids can be employed to advantage. Stereograms, models, perspective drawings can all be applied here with considerable success.

One of the great problems which confronts the teacher is how to ensure that his pupils have a sufficient familiarity with various materials. Expense and inaccessibility are two of the many factors which tend to prevent this. Museum visits and school expeditions help to provide it, but these have obvious limits. Textbook illustrations are too infrequent to give a visual conception related to the many verbally presented ideas with which the pupil has to struggle. The result is that, in many connexions, what ought to be a rich concept presenting many visual facets remains an insignificant perceptual idea which, through its meagre nature, may act as a limiting factor in the process of learning. As an example we may recall that many history books contain a few pictures of famous buildings. Usually one has a single view of the outside of, say, a large building. How is the child to be enabled to get an understanding of internal structures in such a situation? The answer can only lie along one line, by enriching experience through the use of visual media, such as the filmstrip. One does not seek in this way to teach details; instead it is an accepted aim to give a greater degree of understanding through wider experience.

One of the greatest values of visual methods is the possibility of providing a stimulus which is dependent upon a new viewpoint. In one sense this may mean a physical condition; for example, oblique air photographs can provide a new interest in contoured maps. Much more important, however, is the ability to put things into new relations with each other because it is in this that the pupil finds many difficulties. At its simplest, this may be no more than putting two visual presentations in juxtaposition (in the manner of the 'before' and 'after' photographs in advertising); at its most complex it may mean the building up of a new attitude with the aid of a whole film. An interesting example of a new and complex problem exists in the teaching of present-day geographical ideas. Air travel, we say, has altered our conceptions of space and time. This is true for those who use it, and for some of the more sophisticated adults of the world. To the child, however, the implications of an Air Age are few. Those who feel it their responsibility to help to develop a new conception in the mind of the child can call upon many devices to help them—and most of these will lie in the field of visual aids, ranging perhaps from new map projections to air-travel films.

In attempting to meet this problem it will be found that much of the difficulty arises from the inability of pupils to appreciate time-and-distance scales or to follow processes stage by stage. Visual methods have an obvious function here. The devices which are available are described elsewhere. Their value lies in their ability to put into simple visual form changes, relationships and processes which may involve a considerable number of factors. The teacher must, however, make it his business to enter into explanation of what the devices mean. Some of the simpler devices are self-explanatory: for example, the image of a ship, shown on the screen, which moves slowly across the ocean, or the line which 'grows up' or moves upwards from a base line when we say–in a film on geometry–'Erect a perpendicular from the point *P*'. Other devices, however, are more complex, such as methods of showing differences in scales of time and distance; the teacher to whom visual aids are comparatively new will require help in understanding how to use them. These more complex devices are described in detail in later sections of this book.

As teachers we often talk of 'going from the known to the unknown' and, even if we sometimes remember that what is known to us may be unknown to our pupils, we very often forget that our kind of mental world is very different from theirs. Visual materials offer help in many ways in dealing with this translation from the known to the unknown. In particular they can be used to present this transition as a series of stages which can be presented in models, in photographs or in diagrams. In our dependence upon verbal presentation we have tended to ignore the fact that the adult mind, more mature, more highly trained and possessed of greater ranges of knowledge and experience is able to take–in one leap, as it were–a bigger gap than the child can. It ought to be possible to appreciate this merely by argument, but a better demonstration can be obtained by putting it to the test.

Stage-by-stage presentation is useful not only in dealing with new material, but as a basis for the revision of old knowledge. It can also be used to provide a method of self-analysis where the processes involved are of a kind which the teacher can photograph or record in some other way. This has been found, for example, in connexion with the teaching of skilled actions ranging from handicrafts to athletics.

It might be well also to point out that visual means can be used in testing. At its simplest this may be no more than projecting an image of a slide and asking what it is. At the other end we have the use of micro-film and film-strip to present problems and even as a method of submitting pupils to a group intelligence test.

We have been concerned with some of the problems which have to be faced by both teacher and pupil and which can be tackled by visual means. Although but a few of the vast number of problems have been touched upon, what has been said should indicate that the potential field for using visual aids is very considerable. It should be noted, too, that the aids needed may be very simple. Many a pretentious film has been made to deal with a point which could have received adequate attention with blackboard and chalk or a piece of plasticine. It will be pointed out here, and repeated elsewhere in this book, that visual aids offer no magic vade-mecum and that they are not appropriate to every situation. They must be used with discrimination, used selectively and specifically. Once a teacher begins to use visual media on every occasion he has ceased to see visual aids as a means to an end and has become confused to the extent of making them ends in themselves. Visual aids, like most things, can be misused, and the most frequent method of misuse is over-use.

It will therefore not be out of place to suggest that in using visual aids the very first step of all—their selection and the plans for their use by the teacher—is of extreme importance. They are likely to be used most appropriately and with the greatest degree of success by those who see clearly a particular problem to which they are appropriate. Where they are used merely in terms of habit or fashion it will usually be found that efficiency has been sacrificed to enthusiasm.

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III

SOME PRINCIPLES OF VISUAL TEACHING AND LEARNING

IF OUR EDUCATIONAL PROCEDURES were always based on psychological theories, we ought to present a psychological theory as a basis of visual education. In fact we cannot do so for many reasons, of which only three need be mentioned here ; first, there is much which we do not yet know about visual perception ; secondly, there is much we do not know about visual learning ; and thirdly, we are equally ignorant about visual teaching techniques. In visual education, as in so many other aspects of education, we have to proceed in an atmosphere of trial and error, ready to learn from our experiences as we lack experiments, and hoping that sincerity of purpose will prevent us from making too many mistakes. Nevertheless we do have some relevant knowledge and experience to guide us, and it is the purpose of this chapter to offer an elementary approach to such points in theory as appear most likely to help us to develop a not unacceptable practice.

From the early days of psychology, when it was strongly physiological in outlook and method, the problems of vision have attracted attention. As a result we are aware of the basis of stereotypic vision, of the differential qualities of peripheral and central vision, of the compelling effect of movement in attracting attention, of the optical illusions to which we are subject, and of some of the properties of colour. These are dealt with in many textbooks of physics, in a number of books on popular science and in some textbooks of psychology. Important as all these are in connexion with visual methods of teaching it is highly probable that other kinds of knowledge are even more relevant, but despite this they are not always applied. This is particularly obvious in the East where, for example, young children are often provided with books in which the print is far too small, where colour is little used or often wrongly used. These conditions are largely due to economic factors and, now that India, Pakistan and Ceylon control their own affairs and are giving so much attention to education, there is hope that they will be rectified.

Our attention however will be more profitably turned elsewhere. Visual perception is likely to be more accurate and more complete when certain conditions are fulfilled. Of these the most important appear to be:

1. The object seen (e.g. a diagram) should be as large as possible.
2. It should be presented in clear, boldly defined lines.
3. Its colours should be clear and deep (well saturated or intense).
4. It should be well illuminated by light that is neither too dim nor too bright.
5. It should be visible long enough for it to be looked at properly.

Those who know something of psychology will be familiar with the idea that, in looking at a picture, we are affected not so much by the separate parts as by the relations between them when seen as a whole; we see the configuration, to use the technical term. It would doubtless be possible to elaborate a whole theory of visual learning and teaching in such terms–in fact it is highly desirable that a unified theory should be constructed, but that is a task for research, not for an elementary review. From our point of view we should take this quality of 'wholeness' and allow it to guide us in making visual aid materials in which it is preserved and not broken up into a meaningless jumble of parts which the child cannot perceive as a whole. 'The wealth of material' which is sometimes said to be present in pictorial charts may, in fact, be of little real value. It may be a barrier to getting a clear conception of the whole and, what is worse, it may lead the child to impose on it some other, and entirely irrelevant, wholeness—just as we sometimes 'see a picture' in the clouds or the embers of a fire. Meaning does not depend upon multiplication of detail. Who has made that more clear than the Chinese artists who with a few strokes of the brush suggest a whole world!

It is equally important that we think of wholeness in relation to a series as well as a single picture or diagram. A series of pictures to illustrate some point in our teaching must have a clearly defined central theme—they must be related to it and to each other in a logical manner understandable to the child. If this condition is not fulfilled the learner is overwhelmed with material which has no pattern of its own and on which he can impose no pattern either. To be presented with too many pictures is like going to a museum without any clear plan of procedure—one is discouraged by the multiplicity of detail. To translate this into action in teaching means that we must, whenever possible, plan our visual aids and not merely collect and exhibit them in a haphazard manner. We must, as it were, seek some theme which will run through our whole series and give it continuity around this central idea. This is one of the functions of a time-chart in history teaching, or of the continuous referring back to an outline map to locate the position of places seen in a long sequence of pictures of a foreign country. For the same reason the use of 'key' pictures is suggested in planning the content of filmstrips as is shown in Chapter XIII.

Another important finding from psychological studies is that, despite many attempts, no one has shown that individuals can be classified into clearly demarcated perceptual types. Among ordinary people with the usual kinds of unimpaired senses and normal intelligence it is not found that some are pure 'visiles' (visual learners) or pure 'audiles' (auditory learners). There are none who have perfect abilities of space perception while others have no such ability. These characteristics (which derive partly from physiological and partly from psychological sources) are shared by all of us and we differ only in the degree to which we possess them and not by the kind we possess. The implications are clear: that though some children may learn better from visual and others from verbal materials it is wise to let all children experience both, for most children will learn from both kinds of experience. We need to present our materials in as many media as we can, because such enriched experience through multiple avenues of learning allows one form of perception to bolster up another, and this may lead to greater understanding.

A number of interesting and important problems arise when we consider the relations between percepts and concepts or between the 'concrete reality' and 'the abstract idea'. Into this field, so important in psychology and philosophy, we cannot enter; but we can, as it were, lean over the fence and learn a thing or two. We all know that (in a very simple analysis of the situation) words stand for things. Much of education is concerned with things—our school-books are about things—but they are all presented in words, in abstractions. What evidence have we that these words bring to the child's mind any impression of the reality? And how devoid are most of the books we use of any attempt to bridge the gap between abstract and concrete—because they have so few illustrations! Our use of visual aids aims at bridging that very gap; but it will only do so if we have the right aids and use them properly. In learning to use them properly it is extremely important to realize that we must play our part in the process. The relationship between a map and a piece of countryside is clear to us, but not to our pupils; nor, indeed, to many adults. Our visual aid is very often merely another and less familiar abstraction. Thus we have an important rule: use concrete and abstract together whenever possible. Use a map, but not only in the classroom: take it out into the country. Use a diagram, but also have a representational picture at hand, and a model, and the real thing too if you can.

For those who are becoming concerned about the visual approach to teaching for the first time—which will be true of many teachers in India and Ceylon—it is more important to deal with our problem in terms of classroom method than to deal with the more theoretical aspects of psychological and philosophical theory. At the same time it is important that teachers should have some understanding of the tricks and devices used by the film-makers, because it is here, consciously or unconsciously, that he depends upon the psychological and physiological qualities of sight and the act of seeing.

The greatest achievement of the film-maker is the illusion of reality to which reference will be made in many places in this book. It is mentioned here in order to point out a possible danger and to refer to some of the factors which bring it about. The danger is in connexion with the interpretation of the screen picture, especially in the motion picture. As adults we have become sophisticated, so that even if we temporarily identify ourselves with the screen situations we are always aware of their unreality. Even if we see a lifetime portrayed in an hour or two, we still preserve our time perspective. Many pupils, however, even when they are familiar with films, interpret them in a manner which distorts reality, as the child who, having seen a speeded-up film of rice-grain growing, becomes convinced that someone has got a new kind of rice which will reach maturity in a few minutes! This is but a simple example; there are many which are far more subtle, so that those who use visual aids must keep clearly in mind the need to do everything possible to ensure that children should get from a film the meaning intended by the film-maker.

While the makers of educational films use simple techniques, the temptation to make use of their enormous technical resources sometimes leads to confusion rather than understanding, just as a static diagram may complicate rather than simplify a learning situation. This is one of the reasons why teachers should play a part in planning and producing educational films. In order that they shall be able to do this properly they must also have some ideas about the simpler technical tricks of the film-maker, and to these we now give brief attention.

With the cinema camera we can control the scales of time, size and place. Time control is mostly used in educational films for slowing down or speeding up. Many actions, such as an athlete jumping, are so quick that we cannot perceive what has happened. By photographing with a high-speed camera and projecting the film at normal speed we get a 'slow-motion' film which allows us to analyse what is actually high-speed motion. Other processes are very slow, such as plant growth. If we take one photograph every five or ten minutes and project this film at normal speed we see the plant apparently growing very rapidly. A very useful trick, which helps us to keep our real sense of time, is the inclusion of a clock or calendar in the picture thrown on the screen.

Control of scale is obtained in various ways. Minute organisms can be photographed with a combination of cine-camera and microscope and thus we see them on our screen magnified thousands of times. Very remote objects, such as the surface of the moon, can be brought apparently near to use with the aid of long-focus or telephoto lenses. Moreover, by the use of lenses of various focal lengths we can make objects look larger or smaller in relation to others by controlling the apparent perspective. The film-maker has two useful tricks at his command which he uses to direct our attention; they are, to some extent, bound up with scale control. One of these is 'panning' the camera, i.e. slowly sweeping the camera round so that on the screen we get the effect we would achieve by slowly turning the head round while looking at the view. This is often used to slowly direct our attention towards a particular spot—a single mountain peak in a range, for example. The other trick is called 'tracking'. In this the camera is slowly moved up towards an object so that, from a first view of the thing in general or over-all terms, our attention is narrowed down to a particular feature which seems to get larger and larger, until at last it fills the screen and commands our whole attention.

To talk of the 'control of place' may appear questionable, if it means only that with films of different places we can bring the world to the classroom. There is, however, another aspect which is usually called 'cutting'. On the theatre stage we are used to a sequence of events which may occur in different places—and we show this difference by a change of scenery from act to act of the play. The film-maker gets the same effect in another way—he merely joins together two pieces of film dealing with different places—and the scene on the screen changes as though by magic! He can use this 'cutting' also to make us jump forwards and backwards on the time-scale, taking us back by showing us a bit we saw earlier, or forwards in time to what we know has not yet happened.

These devices do not merely take us from place to place or moment to moment, as it were. They may also—as we know from seeing entertainment films—have a profound effect upon our emotions. In educational films we are not so much concerned with that aspect of behaviour, but we are, or should be, concerned with attitudes. It is these various devices which, by creating the illusion of reality, allow us to alter attitudes and thus to engage in the socialization of our pupils.

There are two sides to a film—making it and using it. Having seen something of the tricks and devices which can be used in film-making we must now turn to some points concerning the using of film, and other visual aids too.

Are there any general guides which we can use to ensure that we get the best from visual aids? Obviously there must be, even if we do not know them all yet. On the technical side there are many points concerned with seating, visibility, illumination and the make-up of the visual materials, all of which are dealt with in later chapters. Here we are concerned more with classroom method, and certain points seem clear even if we cannot support them with research evidence. Here are a few which appear to be most important, and it will be seen that they are concerned with children's reactions, behaviour and interests rather than with the nature of visual aids—

a very fitting emphasis if we are to act in the belief that visual aids are means and not ends.

1. What we present to children must be of interest to children, or must at once arouse interest because interest not only commands attention but also arouses effort, and effort is the first step towards achievement.

2. We must strike a nice balance between what is understandable in terms of the child's experience and what sets a problem which must be solved before it can be understood. In other words what we offer must not be so easy that it becomes boring nor so difficult that it becomes disheartening.

3. What we present must challenge a response. It must demand activity and we must not remain content with the purely passive response of remembering. Learning is an activity, not a submissive absorption.

These, of course, are conditions relating to the type of material we use. Now let us turn to the mode of using our materials as teaching and learning aids. And here let us note that almost everyone has different opinions because we lack conclusive research ; indeed, there may be no 'conclusive' research because conditions, teachers and pupils all vary ! Despite this it appears as if the following points are not irrelevant.

1. The teacher must know what he wants his visual aids for and be familiar with them ; just as we must know our subject, so must we know our films.

2. We must use visual aids for our purposes, not let a film-maker dictate to us. His film aims at a sort of average situation, but we have a particular situation of our own. Hence we must be prepared to cut out the sound and give our own commentary, to neglect parts of a film or filmstrip and concentrate on what matters to us. We might

even alter the sequence to suit our needs—providing we can build a frame of reference in which meaning is preserved.

3. We must prepare the way—by talk, chalk, discussion and reading; otherwise our pupils may merely end up in a muddle.

4. We must never expect all pupils, or perhaps any pupils, to get everything out of a film, a filmstrip or even a single picture on a single occasion. Hence the need for a preview, a quick run-through of the film or strip as an orientation. Next, one or even several showings, part by part if necessary, with analysis and discussion—and criticism. Finally another run-through to put the parts back together as a whole.

5. We must seek an active response. Discussion is but one form of this, but there are others: making a model, searching the library for other relevant materials, writing a story, going outside the school to reality itself, even trying to write a better script for a film on the same topics.

We can look at the question of using visual aids in other ways too. Why not use films for revision work? The film, by its vast power of suggestion, its speed of presentation, and its arousing of interest, may do more than the drudgery which revision usually is. It may well be that we could use visual aids a great deal more in testing than we do; certainly the epidiascope could be used in this way. Most important of all is the need for the teacher to realize that the film, and other visual media also, can be used to deal with abstract ideas. It is true that we can only photograph things, but we can arrange these things so that they will be the stimulus to thought and so to abstract ideas. The film—and most of the visual aids which we use—are ready-made for us. Using them in a background of abstractions, to illustrate general principles, depends upon us. It is our task to carry out the most important of all functions in using visual materials, that of integrating them with each other, with other teaching materials and with the general content of education. This we can only do when we ourselves see the links and relationships and when we help our class also to see them.

Though we have turned to visual aids in education largely because education has been too abstract, their use should nevertheless lead to a more verbal approach, but of a better kind. It will be shown later that without adequate verbal support visual aids may not add to understanding (Chapter XIV). We must therefore use words as being still the best medium with which to handle ideas. Instead of using reading, telling and remembering we must use co-operative discussion, criticism, analysis and synthesis. Our film or model must be treated not as a single concrete thing, but as an idea to be talked about, to be related to experience, to be compared and contrasted with local conditions and personal knowledge. Only if we ourselves, as teachers, take an active and constructive attitude will our pupils do more than be passive lookers-on at a new visual scene.

Ideas of this kind need to be translated into modes of practical action, but it is more difficult to lay down hard and fast methods which must be followed. In fact it is also unwise because visual materials, pupils, teachers and local conditions all vary. Despite this however we must attempt to develop some kind of general procedure. This may be best described by taking actual cases.

Using a Filmstrip

Let us imagine that we have a filmstrip on 'Clouds': how shall we use it?

If we believe, as every good teacher should, that learning is an active process, we must frame a situation in which active response and active initiation predominate over passive acceptance. In other words, we do not merely 'show a filmstrip', but we must set out to *use* it. In a situation such as we seek, it seems to be appropriate to progress through four stages:

1. *Orientation:* the building up of a 'set' towards the subject.
2. *Viewing:* examining the strip.
3. *Interpreting:* discussing the contents, the problems they solve—and the ones which are left unsolved.
4. *Response:* actively stimulated by the strip, which aims at extending understanding and problem solving.

These stages we can now consider in more detail.

1. *Orientation.* We shall obviously be using our filmstrip in a predetermined situation—a geography lesson on the weather, a physics lesson on atmospheric humidity, a social studies lesson on modes of living, etc. This will, in itself, give us some setting, some kind of background and approach. More is needed—and this must, if possible, come from the experiences of the class. We must seek it through questions and through discussion. What are clouds? How are they formed? What kinds of clouds do you know? What is their relation to the weather?

After some such discussions it is a useful, and often a valuable, experience to make two brief lists—of the known and the unknown. The contents of these lists will vary according to circumstances, the class and so on. For illustrative purposes we can use two possible samples:

(i) *What we know about clouds*

They are composed of water drops in the air.

They move along through the air.
Some kinds are associated with rain storms.
Others are typical of fine weather.

(ii) *What we do not know about clouds*

Why some move in one direction while others are at the same time moving in another direction.

How high they are in the air.

Why 'rain clouds' do not always bring rain.

Why they sometimes disappear very quickly.

It will at once be seen that the collective experience of the class does not cover all of the more common knowledge about clouds. Our lists contain, for example, no reference to ice-particles. This, and other points will be part of the informational gain that we expect the filmstrip to give—but which it is not likely to give if the teacher fails to use it in a constructive manner.

2. *Viewing*. It is assumed that the various physical conditions of viewing, as described elsewhere in this book, will be fulfilled, so that our concern here is with the teaching conditions only.

A well-constructed filmstrip should have a logical unity of its own and this must be preserved. For this reason it is usually wise to go through the whole strip first, fairly quickly, to get an over-all view of the contents.

This can well be followed by a short discussion which should aim at deciding whether the strip can conveniently be treated as a series of functional sections, each a separate topic, but together making a whole. The better examples of the more modern teaching strips are so constructed that this pattern is at once apparent, and it is frequently indicated by the interspersion of titles, the use of dividing blanks, and so on.

The next stage is that of looking at and talking about the separate sections of the strip. Whether a single section should be dealt with in one lesson, or whether half or all the strip is to be used, must be decided in terms of each situation. A well-informed class of able children of advanced age can obviously use more material in a given time than one of less able and less well-informed children. There can be no general prescription, other than the obvious need to fit the usage to the class and not allow the strip to dictate how it shall be used. At some point the strip should again be viewed as a whole.

One of the misfortunes of visual education is that we do allow it too often to dictate to us. This is particularly seen in the fact that we use communal viewing to the almost complete exclusion of individual viewing. After a filmstrip has been shown it should be made available for any pupil who wishes to see it by himself. Unaided visual inspection is possible and a reading lens will help, but the filmstrip viewer, described elsewhere (Ch. XII), will be found the most suitable device.

3. *Interpretation.* It will be found that discussion may be profitable even while the strip is on the screen, but greater opportunities arise in post-view discussion. The form this will take will depend on the purpose of the lesson, the type of strip and so on. It should also be centred round the two lists prepared during orientation work: How far has this strip confirmed the knowledge originally available? How far has it answered questions and filled gaps? This is the obvious place for the teacher to introduce his points, to raise problems which the class has not appreciated, and so on.

4. *Response.* Seeing a filmstrip ought to be a challenge to action which can take many forms: keeping a weather record or cloud chart; drawing and painting various cloud types; making and checking predictions; finding

out about humidity, condensation, dew points–even making artificial clouds. Nor must other activities be overlooked: extended reading, collecting old sayings about the weather, and so on.

Alternative Methods

It must not be thought that the mode of procedure in using a filmstrip described above is the only one possible. It has already been pointed out that hard and fast rules for a rigid scheme should be avoided. The important thing is for the teacher to be familiar with the material he proposes to use and to have some plan as to how he will use it. This plan should be based on the idea that learning is an active mental process, and not a passive acceptance of what is told or shown to the class.

For our second example we can take a film, such as 'The Principles of Scale Drawing'. Making drawings to scale is of importance in many ways to many people–map-makers, town-planners, architects, engineers, carpenters, builders and so on. Because of its importance to them it is also important to us who are none of these things, but who need to know what a scale drawing is and how to use and understand it. Every child at school in the West learns a little about scale drawing, and as education spreads and technology develops children in the East will have to understand scale drawings also.

The film on 'The Principles of Scale Drawing' is a black-and-white 16mm sound film which lasts for ten minutes. The film-makers provide four pages of descriptive notes.

The first job is for the teacher to get to know the film by (1) reading the descriptive notes; and (2) having a preview of the film.

1. *The descriptive notes*

(i) The introduction stresses that there are two aims, first to illustrate the values of scale drawing; secondly to demonstrate its principles.

(ii) Also it points the need for a *motivating interest* as a basis for successful learning.

(iii) The story: high school students are holding a charity fair and need to build an exhibition stand. Working with a rough sketch they get into difficulties.

One student says a *scale drawing* is needed and he then shows how it is made by doing it step by step.

Commentator shows that a scale drawing is a very useful visual language which can be used for many purposes by all who understand it.

2. *Teacher's preview of the film*

Here the teacher will find out three things:

(i) That the approach is through interest, through a felt want, through a problem situation in which students have got into difficulty and want to know how to get out: they are *ready* to learn by experience.

(ii) That the film makes clever use of animated diagram as well as of natural action photography.

(iii) That the film is built up on a carefully selected and managed series of sequences:

(*a*) Setting the problem in terms of student needs.
(*b*) The rough drawing.
(*c*) The tools needed to make a scale drawing.
(*d*) What a scale drawing is.
(*e*) How to make a flat drawing of a solid object.
(*f*) The idea of scale.
(*g*) Making a scale drawing.
(*h*) Scale drawings as a language used for many purposes.

3. *Deciding how to use the film*

Here we go back to the descriptive notes which suggest:

(i) Preview the film with one or two members of the class and discuss it with them, taking their reactions as a guide for future work.

(ii) Preparatory work with class: discussion, maps, plans, ideas of similarity, ratio and proportion.

(iii) Show the film. Discuss for five to ten minutes.

(iv) Show again and discuss in detail at greater length.

(v) Arrange for follow-up work of two kinds:

(*a*) Discussion on such topics as:
  Why is the idea of similarity important in scale drawing?
  In what other ways are scale drawings useful?
  What tools are needed to make a scale drawing?
  Why is a 'rough sketch' of little use as a basis of action?
  What factors must be considered in the choice of a scale?
  How does a scale drawing deal with the fact that objects are solid?

(*b*) Activities such as:
  Getting help from someone who can bring blueprints, etc. to the class and talk about them.
  Finding out how scale drawing is used by engineers, etc.
  Making scale drawings which will be helpful to the school or the playground, field, garden.

4. Use the film on the plan chosen and note with care for future guidance any parts which require modification.

To many teachers this will appear as a very elaborate plan involving them in much hard work; but all who have made successful use of films know that such detailed preparation is essential and that, with experience, the time and effort involved is greatly reduced. Once again it must be emphasized that the method of procedure suggested is not the only possible one. It is a guide for the beginner which he can modify as his experience of using films increases.

IV

VISUAL METHODS IN THE TEACHING OF SCIENCE

Using Visual Aids in Science

THE PRINCIPLES which should govern the use of visual aids in the classroom have been discussed in previous chapters. These principles are to be used as a guide in any subject, not only in science. There are a few points to which attention should be specially given in relation to science, however.

In many subjects, and in some aspects of science too, the pupil is largely concerned with learning to remember facts rather than engaging in constructive thought. But in almost any learning situation there is, or should be, a problem. It is this problem which ought to stimulate thought. Films–and any other visual aid–are best used in science when they not only provide demonstration and confirmation, but when they also stimulate creative activity by problem setting. Visual aids should then be used, particularly in science, in this way. They are not merely to be looked at and remembered. They must be considered in as critical a manner as possible. The right questions must be asked, the problems must be located and noted and the class should discuss the question as to how far the film treats its subject successfully.

Once again pupil participation should be stressed. They should not merely see science films, diagrams and models but also help to make them. And they should take part in the discussions of the design and content of the visual aids to be made.

Finally we might note that the school's scientific society might well be able to contribute to the making and using of visual aids in connexion with science teaching.

School Science in India and Ceylon

Science teaching in India and Ceylon is, in general, characterized by certain special features. In brief these are:

1. It is formal and academic with far less emphasis on its human relations than is the case in the West.
2. It is far more theoretical than practical, and note-taking and the copying of blackboard diagrams play a bigger part than experimentation.
3. Demonstration plays a large part, especially in the early stages.
4. Laboratory equipment is less extensive than in the West.
5. Science teachers are not in the habit of making their own apparatus and their skill in laboratory arts and crafts is often too little for them to do the simplest glass-blowing or improvisation.

These conditions are the result of a number of factors. Lack of funds prevents the provision of adequate resources. A verbal tradition emphasizes the theoretical aspect of science. Certain ideas of occupational status, which arise from the caste structure of society, tend to dissuade the science teacher from handling tools and making things for himself. The raw materials used in making one's own apparatus are not readily available. Science teaching in university and training college is somewhat formal and little attention is given to teaching students anything of the laboratory arts; and very few teachers have a professional training in the art of teaching. It is with these conditions and factors in mind that this chapter has been written.

In general terms it may be said that science teaching in schools ought to fulfil three major aims:

1. It should provide a training in scientific method.
2. It should emphasize the importance of the application of scientific knowledge to the affairs of human living.
3. It should give to the older pupil some understanding of science as an aspect of the culture of the modern world.

In attempting to achieve these objectives it must be realized that, in addition to the difficulties inherent in science itself and the conditions of science teaching in India and Ceylon, there is another factor which operates in the East. We may conveniently refer to this as the conflict between unscientific and scientific culture patterns.

Education is not yet widespread in the East, scientific education even less so, and a vast majority of people are untouched by the attitudes which spring from a knowledge of Western science. As a result beliefs in anthropomorphic ideas, in the influence of omens and portents, in magic and the supernatural are widespread among the more backward people. Even among those who have received a high standard of westernized education there are beliefs (fundamental in type and sincerely held) which are in conflict with the objective attitude of the educated westerner.

While it is not our task to attempt to resolve this cultural conflict it should be an accepted aim among teachers to show the social significance of science and to back up the widespread attempts now being made in the East to improve the hygienic standard of living, food production, dietetic habits and other conditions which contribute to improved health. Science teaching has a large place in

Finally we might note that the school's scientific society might well be able to contribute to the making and using of visual aids in connexion with science teaching.

School Science in India and Ceylon

Science teaching in India and Ceylon is, in general, characterized by certain special features. In brief these are :

1. It is formal and academic with far less emphasis on its human relations than is the case in the West.
2. It is far more theoretical than practical, and note-taking and the copying of blackboard diagrams play a bigger part than experimentation.
3. Demonstration plays a large part, especially in the early stages.
4. Laboratory equipment is less extensive than in the West.
5. Science teachers are not in the habit of making their own apparatus and their skill in laboratory arts and crafts is often too little for them to do the simplest glass-blowing or improvisation.

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On the informational side we can use visual aids to supplement the insufficient equipment characteristic of the East. We can also use them because, as we saw in Chapter II, they possess characteristics which we can apply to specific situations and difficulties. Science, even in its earliest stages, is characterized by complexities which in the East are magnified because they may not be a part of everyday experience. These complexities we can reduce with the aid of charts, models, diagrams and photographic materials. It is often important for the pupil to appreciate the relationship between the 'test-tube situation' of the laboratory and the industrial application of this in the factory. Where factory conditions are not at hand we can face the situation with the aid of the film and the filmstrip.

There is an important point which should be made clear in connexion with the use of visual aids in science teaching in the East—though it is relevant in relation to other subjects also. While technology and science are rapidly advancing they are by no means part of everyone's common experience. It might well be said that everyone in the East would benefit from some kind of scientific education, but this should be simple and have reference to rural non-technical conditions. It would be a grave mistake to make too wide a use of the science-teaching films which have been made for use in highly technical culture patterns such as the U.S.A. It would be well also to stress here another point which is often overlooked by those who are concerned with the teaching of scientific method. This point can be put in a simple statement: science is not so much a way of doing things as a way of thinking about them. As teachers we are often so concerned to ensure great accuracy in weighing or measuring that we overlook the thought which should underlie these activities and are content to accept what may be slipshod and uncritical.

It is not suggested that we should do less practical work —there is already far too little of it in the schools of India and Ceylon. Laboratory work by the pupil and demonstration by the teacher must play an important part in science teaching. Demonstration is, in fact, one aspect of the visual approach which is often overlooked. Our aim should be to make greater use of demonstration and experiment and to use visual aids to supplement this work. The two should be complementary, but we should avoid allowing the latter to displace the former because, while the film can give vicarious experience, the conduct of an experiment gives direct experience. It might almost be made a rule that, while science teaching needs visualization, this should be in terms of direct experience by experiment and demonstration whenever possible.

In planning to use visual aids in science teaching it is wise to consider what characteristics of science (at the school level) call for visual help and how far this help can be provided by the commonly available visual aids. At the expense of certain repetition we can consider first the general characteristics of science as a school subject and as it is taught in the East:

1. Inadequate facilities for laboratory work.

2. High proportion of untrained teachers who, though aware of the 'classical' university methods, have neither knowledge nor experience of improvisation.

3. Culture-pattern pressure which tends to discount the status value of practical work with the hands.

4. Possibility of conflict between the tenets of Western science and some of the ideals and attitudes of the East.

5. Economic and status-seeking pressures which discount practical work as a means of livelihood, so that, of those who study science, few do so with the idea of becoming scientists.

Apart from these we must recall that science teaching also presents us with other characteristics among which the more important are:

1. Unfamiliarity of content which may lie outside the learners' experience.

2. Complexity of structures and relationships.

3. Range of size from minute to vast.

4. Velocity of processes ranging from the imperceptibly slow to the invisibly fast.

5. Technical difficulties and even dangers in performing certain kinds of experiment.

6. High cost of repetition of experiments in order to ensure that everyone has seen them performed.

7. Seasonal availability of materials in biology which often forces the teacher to observe the calendar rather than the logical relations of the subject-matter.

8. Difficulty of linking classroom science with the science of industrial organization, public health and the like.

9. Operation of a time factor, for example in biological and horticultural experiments, which makes demonstration of certain events difficult or impossible.

10. Difficulty of demonstrating the relationship between science and human affairs.

From the previous discussion, in Chapter II, of problems in learning which can be helped by the visual approach, it will be appreciated that visual aids are of particular value in the teaching of science. It will not be out of place to make further observations of certain points.

The importance of direct experience and adequate demonstration in science teaching is obvious. Wherever this cannot be done in real terms, then it should be done through visual methods : model, film, filmstrip and so on. Even when a real demonstration can be made it may be desirable to call upon visual aids to ensure that everyone has seen it. Small-scale work, for example in dissection in zoology, can be seen simultaneously by only a small number of pupils. The use of wall charts, large photographs, filmstrip or film are ways of overcoming this particular difficulty.

The problems which arise from complexities of structure or process, which commonly present difficulty to the science pupil, are susceptible to visual treatment in terms of analysis. Analysis of this type can be used in various ways which are of beneficial value to the pupil even in what to the teacher are quite simple situations. Take, for example, certain elementary ideas in magnetism, such as the behaviour of like and unlike magnetic poles. We demonstrate these with suspended magnets and with iron filings. We later proceed to talk about the magnetic compass and its behaviour and of the earth's magnetic poles. We are saying, in other words, that the earth itself is a large magnet. Even if we put it into such direct words many pupils, especially at the start of their scientific education, find it difficult to think of the earth as a magnet. The word magnet brings to their minds a bar or horse-shoe magnet, and perhaps an electromagnet. None of these appears to be in any way like the earth! We must obviously go beyond the merely verbal and give some simple diagram of the earth as a magnet, as, for example, in Fig. 9. This form of elementary analysis has application at many points in science of all kinds. The structure and working of the electric motor, the dynamo and the internal combustion engine, for example, can be reduced to very simple terms by visual analysis.

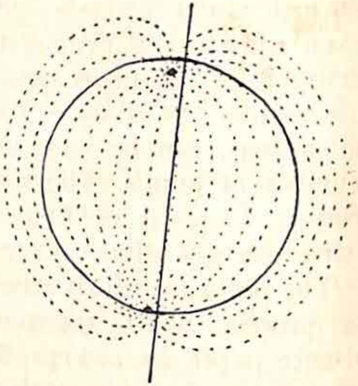

Fig. 9. A diagram of the earth as a magnet with lines of force indicated.

We must however anticipate a point which is more fully dealt with later (see Chapter XIV). Analysis of the kind suggested above is carried out by the teacher in adult terms. Our simplifications may however be as much beyond the pupil's comprehension as the original thing itself! The child looks at a petrol engine and sees its parts—or some of them. The adult looks —and thinks about the cycle of gas intake, compression, explosion and scavenging. This suggests that our analysis must not jump direct from the concrete reality to the abstract theory. We must follow a gradual course and make use of several devices. In our example, a petrol engine, we should start with the engine, then use an exploded drawing of its assembly, next perhaps a simple plywood model, and only then come to a more skeletal treatment of the 4-stroke cycle. Moreover we must not neglect to recall all the 'fringe knowledge' which is relevant and important. It might be helpful, as a guide for the analysis of other things, if we set out the materials and methods we might call on in dealing with the petrol engine.

First, the basic facts of structure. A 4-stroke petrol engine consists essentially of :

1. A *cylinder* in which the gaseous cycle takes place.
2. A *piston* which by moving up and down in the cylinder alters the pressure inside it and gives direction to the kinetic effect of explosion.
3. *Valves* which control gas-flow into and out of the cylinder.
4. A *spark plug* which produces the spark to ignite the gas in the cylinder.
5. A *connecting rod* which connects piston to crank shaft.
6. A *crank shaft* which, by its 'throw', converts the linear travel of the piston to rotary motion.
7. A *fly-wheel* which stores the energy of momentum.

Second, we must recall to the minds of our pupils some of the fringe ideas which are necessary in order to understand the internal combustion engines. For example :

1. Mixtures of certain gases with air are explosive (recall the usual school experiments).
2. The temperature of a gas rises when the gas is compressed (cycle pump).
3. Increasing the volume inside a closed space reduces the pressure inside it (piston moving down cylinder).
4. Gases travel from regions of high to regions of low pressure (thus the cylinder is alternately filled and emptied as the piston moves).
5. Direction of movement can only be altered by the application of a force (thus the momentum of the rotating fly-wheel causes the position to move alternately back and forth).

Third, we must decide what ways we propose to use to lead to an understanding of the petrol engine, such as:

1. Watching a petrol engine at work (motor cycle on road).
2. Seeing a petrol engine dismantled (visit garage).
3. Seeing an exploded drawing of a petrol engine.
4. Making a plywood model to illustrate movement of parts.
5. Making a set of flow diagrams to show the four cycles.
6. Seeing a filmstrip on the petrol motor.
7. Seeing a film on the internal combustion engine.

Those who want to get the best out of visual aids in science teaching are advised to make an analysis of each topic on lines like these and not to be content with taking just what happens to turn up. The petrol engine of course is not part of the common experience of every child in India, but the same principles can be applied to other topics.

We have been discussing analysis but we must not overlook the need for synthesis in science teaching. Here too visual aids can help us just as much. By using the methods described in Chapters IX, X and XI we can bring together several ideas or several sets of facts and so build them into a single concept of a more complex kind. In doing this we should always use the simplest possible method. We want our pupils to understand a new idea and not to get fogged up in a struggle with complexities of our making. If possible it is wise to use representational and pictorial methods as a basis for synthesis–show relationship by putting things side by side, at least in a picture. Next we can turn to a more diagrammatic approach.

The ability of the film, and other visual aids and methods, to control the factors of speed, size and place have already been mentioned. This is of great value in science teaching and should be exploited as fully as possible. Diffusion, gravitational acceleration, microscopic structure, conditions in the oil-well regions—all can be dealt with in visual terms.

Even though we may not use them in teaching except on a modest scale, we should not neglect to show our pupils how science has depended upon visual aids. Microscope, telescope and camera are instruments which are well known and which have played a great part in scientific recording and research. The cine-camera, especially in slow-motion and high-speed work, has made photography of even greater value. Nor should we neglect to mention such things as X-ray and infra-red photography.

One of the fields of school science where visual aids, particularly the film, can play a very important part, is in dealing with the social relationships of science. As our ability to fight and control disease has increased so has our knowledge of the world and our exploitation of its resources and living spaces. As we have applied our scientific knowledge to the problems of agriculture and health, so have our standards of living been raised. These verbal statements can be made more real by the use of the film. Moreover, with the film we can affect the attitudes of people and so make more social progress more possible. Improving the health of the villager and helping him to grow more food is only possible where people's attitudes towards these possibilities have been changed. The emotional appeal of the film gives us a potent weapon for changing and re-orientating attitudes. We can make people realize that the problems of science are their concern, that science affects them and that, through methods which are often the merest variations from traditional methods, their lives can be made better. It is particularly important to do something of this sort in the East. Science and technology are largely the products of Western culture and we are too inclined to think of them in Western terms. If, in our teaching, we present applied science only in terms of atom-smashing and supersonic speeds we shall have made but a poor contribution to life in the East. We must put science into the homely terms of the common environment of the East. Jet planes, diesel trucks and turbolocomotives are the result of a scientific attack on the problems of transportation in the West. But the East has its transport problems, too, in which the limiting factors are the design of carts and the speed of the bullock. Science teaching in the East must not neglect such homely problems as the improvement of wheels, the better designing of axles or the making of lighter and stronger carts and trucks. We must use visual means to show that these problems are vital, local and worth attention.

From these rather general aspects of our problem we may now turn to more detailed aspects in terms of the various science subjects. The most commonly taught school sciences are biology, physics, chemistry and mathematics. In each sphere, visual aids have a contribution to make, not merely in terms of the film, for which we are dependent upon commercial production, but also through the simpler methods of filmstrip, picture, diagram and model.

Visual Aids and Biology

Biological science is particularly adapted to visual methods of study and presentation. Because of this, and because many of its problems can be understood by the layman and have a wide general appeal, the production of visual aids (especially films and photographic surveys) in science reaches its peak in the biological field.

The particular characteristics of biology, at the school level, which make it so appropriate a subject for visual treatment are as follows:

1. The effect of seasonal factors on life histories, development and availability of material. The calendar and the curriculum cannot always be kept in step with each other and the needs of revision frequently call for materials out of season.

Here visual methods can come to our aid in the form of photograph, film, model and diagram.

2. The cyclic periodicity of events such as the nitrogen cycle or the life histories of parasites often appear to be confusing to the pupil.

By visual analysis and synthesis in various forms we can overcome these difficulties. The lengthy verbal presentation of the life history of the malarial parasite can be reduced to a process diagram which, if adequately labelled and described, gives the story with a minimum of effort and a greatly reduced chance of misunderstanding.

3. The complexity of structures, relationships and functions can all be dealt with in visual terms. Models, enlarged drawings, stereograms and overlay methods will be found of particular use in this connexion. (See Chapters X and XI.)

4. Variety of scale presents the biology teacher with special problems; his material may vary from the protozoan to the elephant! The use of visual aids is obvious.

5. Unfamiliarity with biological material presents special problems in certain connexions. We may take one example–evolution. Some understanding of this central

biological theory is important, quite apart from the examination aspect. Such understanding however demands an acquaintance with past life-forms and with living forms which are often restricted to distant places. Here again model and photograph can come to our aid.

The kinds of visual aid we may use are many, ranging indeed over all that are available. What these are may be seen from other chapters in this book and there is no need to repeat them here. Two points which should be noted are : (i) there are endless opportunities in biology for using models and stereograms, both of which have been neglected by teachers ; (ii) every opportunity should be grasped of letting pupils participate in the production of visual aids for the teaching of biology. In particular, attention might be drawn again to the great neglect by the biology teacher of the model and the stereogram. Both are described elsewhere in this book, both can be produced easily and cheaply, neither calls for great skill and both are invaluable in dealing with structural problems in morphology. Another device to which attention must be drawn is the perspective-drawing apparatus described in Chapter IX. For biological work this is of very great value.

Teachers will naturally want to know what visual materials are available in relation to biology teaching, and from where they can be obtained. Somewhat sketchy answers, which cannot possibly be up to date, may be obtained from the Appendix. It is possible to give some guidance as to what kinds of biological visual aids are available from commercial sources, whose addresses are given also in the Appendix.

Films. 16mm films on biological subjects were among the earliest produced for education purposes and now form the largest proportion of teaching films in the sphere of science. They are produced as sound, silent, mute, black-and-white and colour films. Mostly they are of one reel (400′ or 120m) length though some have been produced as a series of one reel films on various aspects of a single topic. Most biology films deal with natural history, field work and the behaviour aspects of living organisms. The laboratory aspects of physiology, experimentation, and so on, have been less fully covered.

There is considerable need for many more short films—even of a single minute's duration. There is also opportunity for making loop films to deal with cyclic events such as chromosome behaviour, cell-division and life histories.

Filmstrips. A large number of biological filmstrips is available covering many aspects of biology. While they miss the kinetic aspect dealt with by the moving picture film they are still of very great value. For many purposes, for example in connexion with dissection, morphology, systematics, ecology and embryology, they may even be more valuable than moving pictures.

The teacher should note that he can easily make his own filmstrips and that for some purposes it is not even necessary to use a camera. Even the photographic procedures can be reduced to a minimum of simple operations.

Lantern slides, though still much used, are declining in popularity with the appearance of the filmstrip. For those who prefer the protection and ease of rearrangement of a series of single glass slides the miniature slide will do all that the standard slide will do and at greatly reduced cost.

Photographs. Most museums and many commercial firms produce natural history photographs of use in biology teaching. The most convenient size to buy is the standard postcard ($5\frac{1}{2}'' \times 3\frac{1}{2}''$ or 140×88mm) because it can be used in the episcope.

Models for the teaching of anatomy and morphology have been used over a long period. They are expensive and therefore not as widely used as their teaching value warrants. Teachers are recommended to explore the methods of model-making described later in this book (Chapter XI) and to make their own with the help of their pupils. Apart from representational models, there is scope for the use of diagnostic models which can be made by simple means.

Wall charts are useful in many ways but few of the commercially produced ones are entirely satisfactory. They are often too heavily loaded with material and the lettering is too small. Teachers can make their own with the aid of the episcope.

It will be seen that these materials call for the use of the complete range of visual apparatus including the micro-projector which is particularly adapted for biological work. As is shown later much of this apparatus can be made by the teacher and his pupils.

Using visual aids in biology. The general problems of using visual aids in the classroom have been discussed already in Chapter II. Three points can be specially emphasized :

1. Get pupils to help in the making of visual aids for biology teaching. It is an excellent way of learning. They can make models, wall charts and enlarged drawings.
2. Never use visual presentation first if the real thing is available. Why see a film on the tadpole when frog spawn is available in the nearest pond or ditch ?
3. Make a detailed list of all the visual aids which you think to be necessary for biology teaching. Then, aided by the class, set out to build up the complete collection bit by bit.

Drawing and biology. The making of drawings by pupils learning biology is an established usage in schools. The value of these drawings is increased if certain points are kept in mind:

1. Pupils' drawings are a way of learning, a method of recording work done and a foundation for revision.

2. Purely representational drawings, which are the most common type, are probably the least valuable.

3. Make use of analytic and synthetic drawings as much as possible.

4. Draw objects and sections from as many view-points and through as many planes as possible.

5. Make serial drawings to show consecutive stages in a process or event, thus obtaining a record which is complete enough for revision. The usual neatly labelled drawing of a finished dissection is far less valuable to the pupil than a stage-by-stage record of every step in the procedure.

6. For identification use key lines and a code of figures or letters with a descriptive legend below the diagram. This can be covered up and thus the pupil is left free to test his knowledge.

7. Do not hesitate to provide duplicated outline drawings on which the pupil can be asked to check items and add names. This helps the pupil who is not very skilled in drawing and saves time for everybody, while it has little if any effect in reducing learning.

8. Ensure that pupils use a standardized scheme of colours in botany and zoology and that their drawings are arranged in a logical manner. Most practical books are a haphazard collection of records. A loose-leaf system or complete and careful planning in a sewn book and an adequate index of contents should be considered essential.

Visual Aids and Physics and Chemistry

Much of what has been said about using visual aids in biology is relevant to physics and chemistry. The emphasis will of course be different as these subjects lack the morphological aspects of biology. However, they offer an excellent field for exploiting visual presentation in other ways, particularly in demonstrating the way in which what is learned in the laboratory is applied on the industrial and commercial scale. Indeed, it is in connexion with the social aspects of science that visual aids, especially the film and filmstrip, are perhaps most useful.

Most of the fundamentals of school science can be demonstrated by actual laboratory experiment and argued out verbally and quantitatively. Their applications in the world in general are less easy to deal with in these ways. And in any case it may be necessary to make up for the lack of experimental opportunity by the use of film, filmstrip, and so on.

It should be the constant and fixed determination of the science teacher to perform practical experiments whenever possible. In fact, in India and Ceylon, because of the shortage of equipment and because of the highly verbal tradition in teaching, experimental work is reduced to a minimum. The vast majority of pupils in elementary and general science classes are introduced to 'science' by blackboard, chalk and talk! Wherever regular apparatus is not available, the teacher should turn to makeshift and 'mock-up' methods. Buckets, bricks, cigarette tins, bottles and jam jars, sealing wax and string can be pressed into service and can be used to give a basis of reality to experiments performed in science lessons. Only after every such avenue has been explored should we turn to escape by other means.

At this point a film may be of great value—but the school which lacks scientific apparatus will probably lack a film projector, and will do so for the same economic reason! If, however, films or filmstrips can be shown, they will do something to overcome the highly verbal nature of school science. Study and demonstration of the properties of water should, for example, be a practical job. Some of the job can be done with very little apparatus but, when it is exhausted, we can then rightfully turn to using a film about the topic.

Film, filmstrip and photograph can be used to enrich meaning and extend the syllabus into the world outside. Mechanics in school, for example, seldom lead to an understanding of the way its principles are exploited in engineering in simple as well as complex situations. A film on the transfer of power or on gearing and pulleys can give an entirely new outlook—and there are many such films available. Moreover, because visual presentation can so well stress the social aspects of science, we can show that such homely things as the bullock-cart present problems to which the scientist should give a high priority.

The diversity of subject within the fields of physics and chemistry is so great that it would be too lengthy a task to specify all the applications of visual aids in these fields. It may be said that there is a place for all kinds of such aids and for all the common visual apparatus. It should also be noted that the study of the principles of operation of visual apparatus is part of these sciences.

The applications of the visual approach in physics and chemistry fall into three groups, as contributing to (i) the understanding of processes and relationships; (ii) the understanding of industrial and commercial applications; (iii) the appreciation of the social significance of science.

These three groups can be illustrated by the following examples :

1. Pupils who are being introduced to the ideas of molecular and atomic structure and valency often learn a series of statements or definitions and can even solve simple quantitative problems without achieving any real understanding. The underlying reason is probably that the ideas are abstract and, while capable of symbolic representation, are not associated in the mind of the child with any structural basis. It is true that we draw diagrams and make use of the familiar 'wire and knob' models, but these do not have the kinetic aspect necessary to reflect the rearrangement of molecular structure. A diagrammatic moving picture film based upon animation can be of great help, although for this purpose a loop film would be adequate.

2. The preparation of coal-gas in the laboratory, or the processes of separation by filteration and distillation, are in themselves simple to demonstrate and explain. The commercial applications of these processes, however, are not easy to follow, especially for those who have not seen the factory set-up. Film or filmstrip can do much to overcome the difficulties.

3. The increasing speed of aircraft has given a new social significance to travel and has virtually made the world smaller. The control of water-flow, the utilization of water-power, contour cultivation, mechanized farming, and so on, have literally made the desert blossom into production. Talk, tabulation and charts can do something to give meaning to these startling results of applied science. Pictorial presentation can make them even more real. The film can give them a personal touch as nothing else can.

It must not be thought that only the filmstrip, or even the photograph, are essential, nor are they the only visual aids applicable to science teaching. Models, charts and diagrams can play a part. One of the most interesting developments in science teaching may be seen in *Visual Science*[1] in which Isotype is used as a medium for problem setting. Every teacher interested in using a visual approach should see these books.

The teacher should examine the materials and methods of visual presentation which are described in other chapters and decide how he can make use of them. The start may be simple and one may never be able to make, or even use, motion pictures; but, despite this, the value of visual aids in science is considerable.

Visual Aids and Mathematics

Mathematics is so essentially abstract that one may well think that, except for geometry and trigonometry, it cannot be presented in visual terms. This however is not so and visual aids can make a most useful contribution. The first step in attempting to increase mathematical understanding by visual means should be through practical work, not that this is strictly visual. It is clear, however, that in this subject, as in so much teaching in the East, the emphasis, particularly in the early stages, is far too theoretical. Through practical work—project work in particular, which calls for much visual work—the teaching of elementary mathematics could be greatly improved even

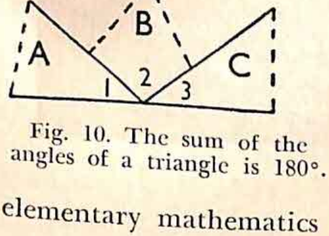

Fig. 10. The sum of the angles of a triangle is 180°.

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[1] Six pupils' and two teachers' books by Marie Neurath and J. A. Lauwerys (published by Max Parrish, London).

by such a simple device as is shown in Fig. 10. Nor is it enough to rely only upon the usual paper-cutting and folding, measuring of desks and classrooms. These are exercises which lack motivation so far as the child is concerned. It is far better to turn to situations which have meaning for the child, such as marking out the pitch for volley-ball or other games, or exploring any situation in which the child has a felt want of his own.

The toys used by children often offer a field for work

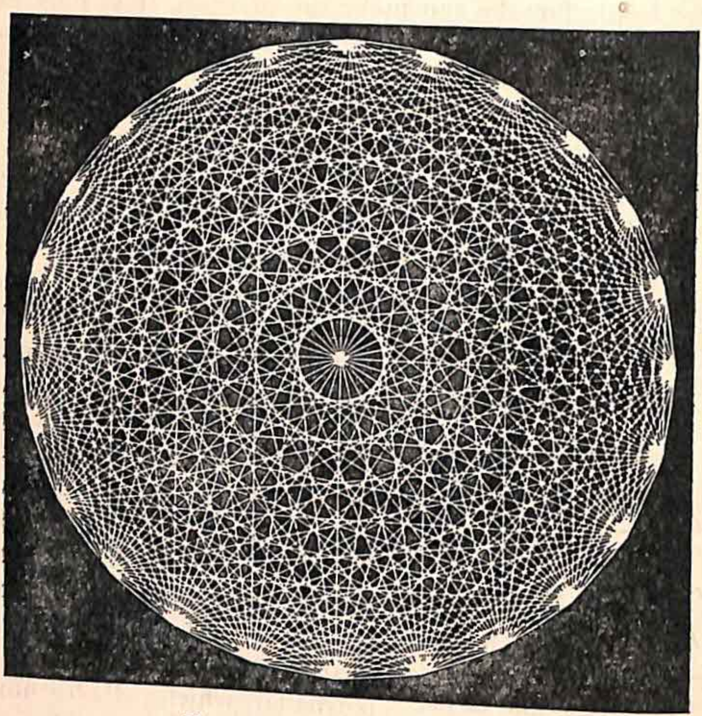

Fig. 11. A geometrical design.

in elementary mathematics. The writer has seen children with wheels or tins attached to the end of a stick. These are pushed along the ground to cause the tin to revolve. This offers a chance of dealing with the geometry of the circle. There are doubtless many other such opportunities such as arousing interest by geometrical designs, as shown in Fig. 11, which was made by drawing in all the diagonals of a regular polygon with twenty-four sides.

From such practical aspects we can then turn to what are more strict uses of visual aids. This field has not been much explored yet. There were no films dealing with mathematical topics until 1936 in England and only fifteen such films ten years later. The production of filmstrips however has proceeded more rapidly, but on different lines. The pioneer mathematical films, though they were visual presentations, were just as abstract as the topics with which they dealt. Thus two films dealing with differential equations present a picture which may stimulate thought, but which is only possessed of meaning for those who already understand how to solve such equations. Since then, films have been made which are more simple and more suited to school use. They tend to fall into two types. One follows closely the lines of mathematical proof as used in the majority of textbooks, as for instance in a series of animated diagrams dealing with the theorem of Pythagoras. The other type attempts what might be called the 'humanizing' or 'socializing' of mathematics, as might be seen from any film which attempts to show the importance and convenience of the idea of percentage in everyday affairs, by dealing with real-life situations.

Filmstrips on mathematical topics are now very common. In general they tend to follow textbook lines but give more diagrams than the normal book can carry. In addition, it is customary to attempt to give some indication of the historical setting in which the particular idea developed and also to indicate some of its practical applications in everyday life. These aspects, historical and social, are important and add greatly to the value of the filmstrips.

In general it may be said that the filmstrip is probably the most useful visual aid for the mathematics teacher at present. The value of the episcope, of practical work and of models should not be overlooked. In particular it is important to stress the application of mathematical ideas in everyday life.

V

VISUAL METHODS AND THE SOCIAL STUDIES

THE CHANGE IN THINKING whereby education has come to mean not only the gaining of knowledge but also the building of socially approved attitudes will be mentioned in more general terms in Chapter VIII. At this stage we merely point out that such a change exists and that it can be seen in various ways—particularly in the realization that one of our measures of success in education must be the alteration of attitudes. Put in practical terms, we may say that the teaching of 'civics' or 'government' may produce better informed citizens, but they will only be better citizens if we have brought about a change in their attitudes. They must feel themselves a part of society and, while more aware of their rights, must also be more willing to shoulder their responsibilities.

In seeking to put their new beliefs into action educationists have sought ways of socializing the curriculum and of integrating its subject-matter more closely. History and geography—which are in fact closely related at many points—tend now to be looked on not as two separate subjects, but as one—'social studies'. Educational literature today includes much discussion of this new subject in the West and one cannot but feel that it must be of equal significance in the East.

Those who teach history and geography are aware of the difficulties of their task, but the difficulties of teaching social studies will not be appreciated in detail until we have greater experience over longer periods. It is, however, possible to anticipate, and thus prepare for, some of these difficulties and to devise means of overcoming them by visual means. The major difficulties are of the following types :

1. The appreciation of social ideas requires some degree of maturity denied to most of our pupils by their age.
2. The understanding of social relationships and concepts undoubtedly needs a fairly high level of intelligence ; but the study of these topics is not, and cannot, be confined to our bright pupils only.
3. The implications of the relationships between social data and events are only to be understood in the light of adequate knowledge ; circumstances force us to teach civics and other social studies long before our pupils have the required background knowledge.
4. The teaching of civics and social studies is too often based on a single inadequate text which fails to arouse interest.
5. Adequate background material is not easy to obtain and tends to be of a technical or statistical nature, such as annual administrative reports.

From the discussion in Chapter II it should be clear that the visual approach has much to offer towards solving many of these difficulties. Complex data can be presented simply, the relationships of one idea with another can be made clear and we can present a wealth of supporting materials of a pictorial kind to give greater meaning to what may be too abstract. The power of the film to mould attitudes and to provide vicarious experience gives some help towards overcoming the difficulties which spring from the immaturity of our pupils. All teachers who want to use social studies as a contribution to social development should consider how far visual methods can help them. In doing so there are two points which must be noted :

1. The complexity of social ideas and the fact that they are often outside the normal experience of children places an emphasis on the need to take every possible step to give meaning to whatever visual aids are used. They can make a contribution only when properly used. To make elaborate charts, complex diagrams or lots of pictures, and leave it at that, is not enough. We must start with simple charts or pictures which deal with big ideas, as for example that shown in Fig. 12. Many of our ideas, and perhaps most of the more complex ones, are cast in verbal terms and, however much we may use symbols, all our arguments must, in the end, be set forth in words. Thus we must ensure that our visual presentation, particularly in the field of social studies, receives an adequate backing up with verbal material. Figures 13 and 14 by themselves would mean little to most pupils, but if the teacher adds a verbal description when using such pictures they at once take on a wider meaning. This will be extended still more by allowing the class to talk about the pictures, trace the changes shown, or even suggest other ways of achieving the same result. Our visual material must be adequately described, we must use the various devices for clarification referred to elsewhere in this book and we must take care that the stages and steps in our presentation are linked together with descriptive material.

2. While we turn to the use of visual aids to provide orientation material, vicarious experience and a wider background we must not overlook the importance of actuality. The child studying social problems is living in a world of social problems. He should not see the latter only through films and pictures—at second hand. He must see the reality, learn by experience and learn at first hand. It is here that local surveys, visits and other kinds of school

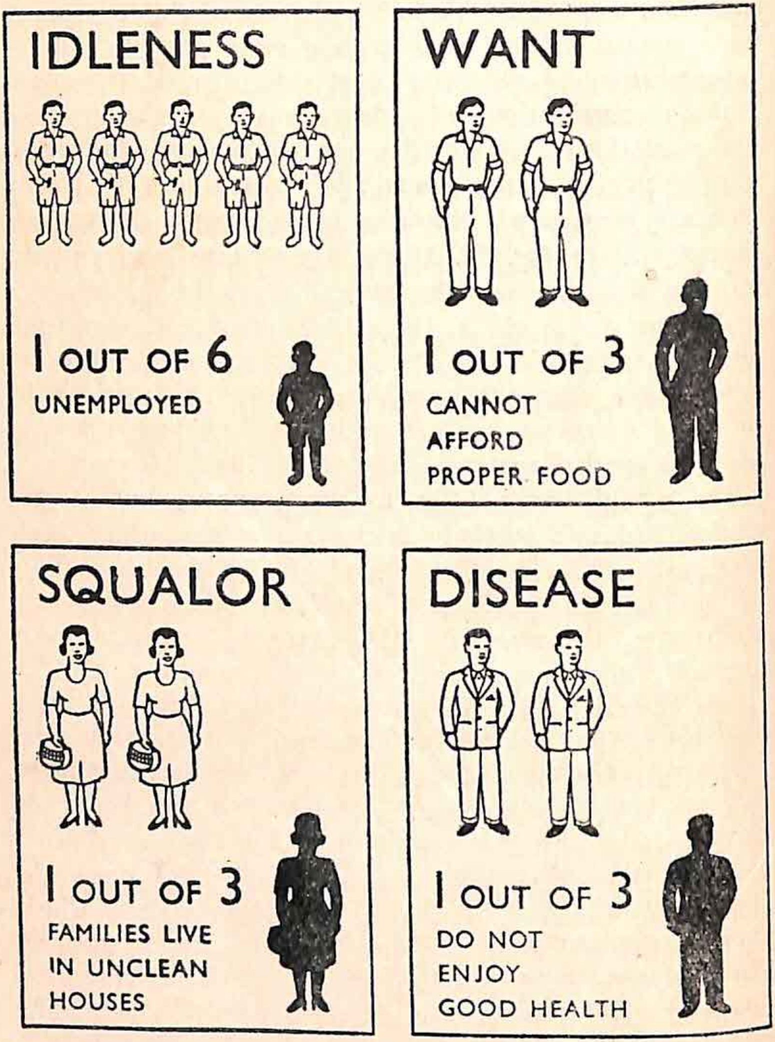

Fig. 12. A simple chart dealing with a complex idea.

activity must be used as an essential feature of the visual background.

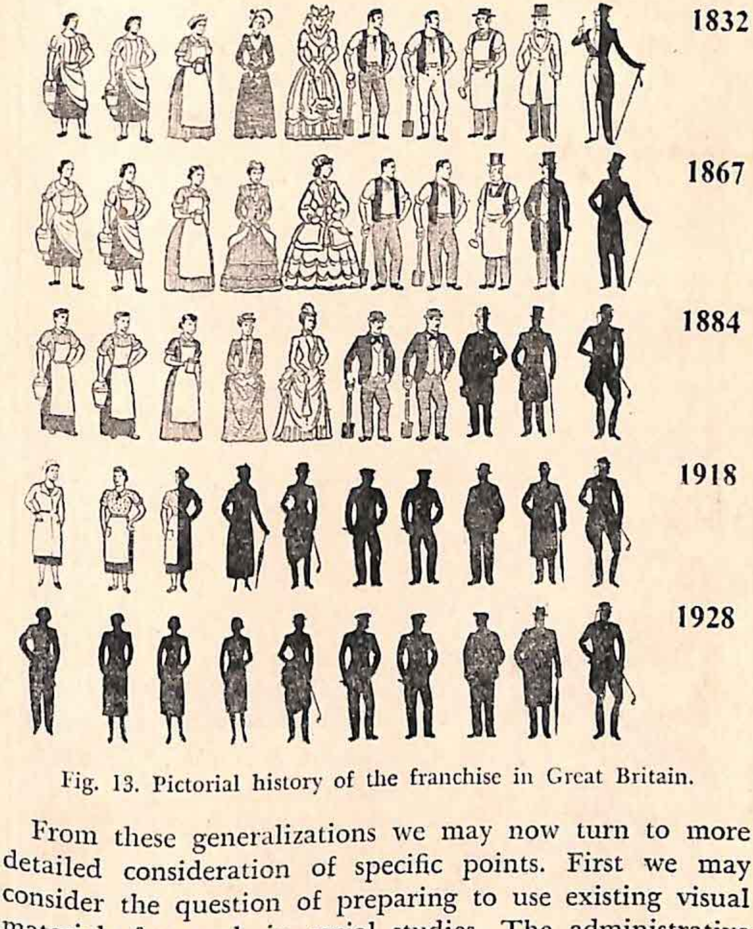

Fig. 13. Pictorial history of the franchise in Great Britain.

From these generalizations we may now turn to more detailed consideration of specific points. First we may consider the question of preparing to use existing visual materials for work in social studies. The administrative aspects of filing, storing and indexing are dealt with in Chapter VIII ; our problem here is to consider what is available and how we can get it. The first task should be

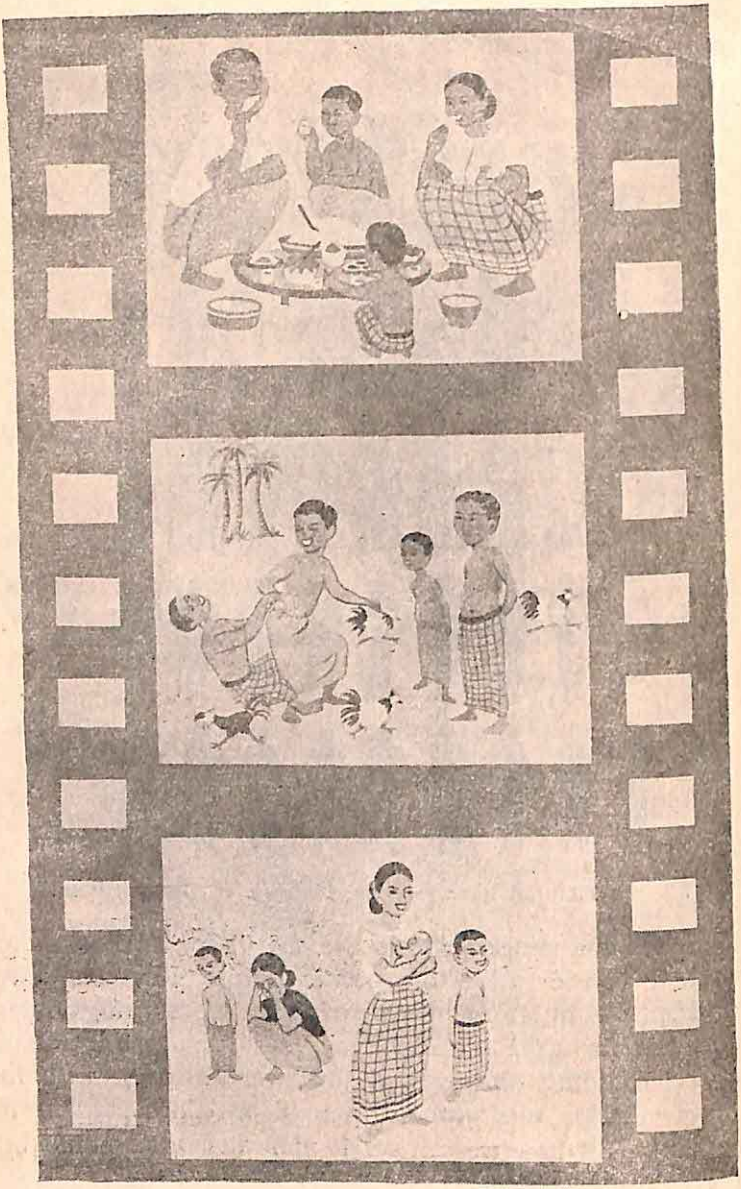

Fig. 11. 'Rice and Health': frames from a filmstrip made by F.A.O.

that of making a list of all the topics which are to be studied in the field of social studies. These should be arranged in the sequence in which they will be followed. Next it is useful to decide what major difficulties they present and to follow this up with a note as to how these difficulties are to be met. Finally we can make a list of the visual materials which would be useful. We may illustrate this method with an example from a teacher's notebook.

Extract from a teacher's notebook—lesson preparations.
Subject : Civics. *Water-supply.*

1. Biological importance of water.

2. The history of geographical explorations of the deserts—a study of water-supply problems.

3. Water-supplies and location of population—deserts —oases.

Australia : dry central zone, wet rim with people.
Ceylon : wet and dry zones.
Clay : position of villages where clay throws out water which has percolated porous upper layers.
Wells : kinds, positions.

Check in school atlas

4. Water consumption : (*a*) Uses of water. (*b*) Water and agriculture. (*c*) Water and industrialization. (*d*) Water and health. (*e*) Consumption and population.

Get local Annual Report from M.O.H. etc.

5. Provisions of water : (*a*) Village wells, pumps and tanks. (*b*) Growth of population needs large-scale storage. (*c*) Roman aqueducts. (*d*) Reservoirs and pipelines.

History books, local histories, maps etc.

6. Local water-supply : (*a*) Geology of district. (*b*) Geography of district. (*c*) Location of local watershed. (*d*) Distribution.

Local maps

7. Administration: (*a*) Costs, control. (*b*) Water and health. (*c*) Need for controls. (*d*) The water rate.

Civics textbook

This is the sort of thing which the good teacher does. However brief, this gives a background for the civics lessons and the civics book in use, and provides some chance that the very inadequate details of the usual school textbooks are seen against a background of reality.

In the example given above certain materials were already available. The next step is to decide what other materials ought to be available to make learning and understanding effective. We may illustrate this with reference to the same topic: water-supply. Whether the child lives in village or city, water is a basic need and the provision of an adequate and safe supply has engaged man's thoughts and activities throughout history in every part of the world. The study of water and its significance to man falls within the provinces of science, hygiene, home science and the like. The study of how we organize our provision of the supply of water falls within our civics syllabus. The importance of many of the points in our study of water under the civics syllabus will not be appreciated unless there is an adequate degree of correlation with the science aspect. Thus we must plan to provide this degree of linkage and cross reference. Also, in view of the importance of experience in learning, we must ensure that, while we use visual aids to supplement the textbook, we also make provision for as much first-hand experience as possible. Our plan of action and its various relationships could then be presented as follows:

CIVICS

Topic: Water-supply

Correlates	*Civics Theory*	*Visual Materials*	*Experiences*
Physical geography	Water-supply	Maps, sections, pictures	Local wells, ponds and springs to be visited
Physics	The reservoirs	Pictures	Visit Experiment on water levels, effect of gravity etc.
Biology	Pure water	Pictures	Visits to collect water samples, laboratory work
Chemistry	Pure water	Books and pictures	Visit waterworks Visit public analyst

This idea is capable of extension in relation to this topic and to many others.

It is not suggested that each topic must be worked out in this formal manner, but at least it provides a framework for thought and allows the teacher to see his task as a whole. In particular it isolates and defines the processes of teaching and shows clearly the various components, visual and experimental. From our example we can see at once what visual material we must make or collect. The methods by which we can do this are described elsewhere in this book, particularly in Chapters IX to XIII, and we shall not describe them here. What must, however, be stressed here is the need to 'let the pupils in on' the process of making the visual materials, because this can be an important part of the learning process. It is a mistake to assume that this would be a waste of time because, properly handled, it helps the pupils to isolate difficulties and do some creative thinking about how to solve them, instead of merely trying to learn (which means remember) in a purely passive manner.

Armed with a list of what we consider to be necessary, and with the intention of getting our pupils to help in the work, we come to the final stage of putting our ideas into action. The division of the work into units based on convenience is obvious and we must also ensure that the special interests of our pupils are properly used. Some will like making models, others mapping, some will be skilled as artists, others in printing; we must share out our tasks in relation to these individual differences and also, as far as we can, comply with individual preferences. In these ways we shall have more chance of a social climate conducive to good work.

In the actual making of our visual materials we must be prepared to use every available source of help. Our textbooks have some pictures, and if necessary these can be enlarged with the episcope. We or our pupils can write to the local health department and waterworks department and try to get reports and posters. From the survey maps of the locality we can get much information and use them in other ways. One map could have our town marked in a special way. With a coloured line we could show how we are linked to the reservoir, and its position. The watershed can be coloured. Then we can make graphs to show the changes in water consumption in relation to changes of population and so on. A contour model would be attractive and useful and would give greater understanding of how differences of level are important in water distribution.

In a village in India or Ceylon the mechanics of water-supply are simple, consisting of the well for drinking-water and the *kulam* (*wewa,* tank) for irrigation. Many of the problems, especially those with regard to health, are the same as for the town and we might well proceed upon similar lines.

In both cases we should do as much as possible to ensure that activity and experience are part of the learning process.

In social studies, as in everything else, we must take the age of our pupils into account. For the young ones our treatment of each theme must be more simple and direct.

We have taken water-supply as a topic to illustrate ways of arranging our work and choosing our visual material, and so far we have stressed what we can make and do for ourselves. It is well to recapitulate this series here:

Activities and Experiences

1. Visit to see a well being dug.

2. Discussions about local wells: 'Ours is shallow and often goes dry.' 'We use a deep one.' 'Some wells have a pulley and rope hauled by hand.' 'We use a well-sweep on which men walk.'

3. Visits to different local wells.

4. Visit to the village tank, walking round the bund, seeing how the ground slopes.

5. Visit to the waterworks, the reservoir, the overspill, the filter beds, the chemical plant, tracing the pipeline, touring the watershed, etc.

Models

1. A well scene made in plasticene.
2. Model of the village tank.
3. Contour model of the district to show water-supply.

Maps

1. Map to accompany the contour model.
2. Map to show spread of the local town.

Graphs

1. Increase of population.
2. Increase of water consumption.
3. Incidence of water-borne infectious disease in various areas to compare well areas with piped water areas.

Pictures

1. Sketches of well scenes, water tanks, *kulam*, etc.
2. Illustrations from magazines and photographs.

Photographic Aids

1. Photographs of wells, waterworks, etc.
2. Filmstrip on water-supply (if obtainable).
3. Film on water-supply (if available).

Local Surveys

The local survey has for long been used in England as a technique for the study of social problems at an advanced level. Recently it has become a common technique in schools which, under the interest stimulated by the Ministry of Education Visual Unit dealing with this topic, is now generally accepted. Interest in this method is not lacking in the East but, because of more formal traditions, it is not yet widely used. As its use spreads there will be an increasing call for ideas concerning visual presentation. As a guide on this point the following section will be enough to indicate general lines of approach.

Purpose. The aim of the local survey is to give practical demonstration and application of the theoretical aspect of social studies, to link textbooks with the world outside and to show the pupil that he is part of a community.

Method. There are many methods for the conduct of social surveys but, despite variations, there is a certain general technique. This consists largely of deciding how the whole subject can be broken up and who shall be responsible for each part.

Visual aids. Visual aids are used in local survey work in a variety of ways but generally with certain specific aims:

1. To give a pictorial background which will lead to some degree of appreciation of the physical and cultural setting.

2. To illustrate specific points, such as how the local houses are built, how people dress, the changes of aspect dependent upon the seasons.

3. To analyse complex data or ideas, for example to trace the social mobility of the area, the changes in ways of earning a living, and so on.

4. To illustrate developmental trends in such things as growth of the area (in terms of administrative boundary, market area and the like), growth in population, etc.

5. To show how various sets of conditions are related to each other, for example climatic conditions and crop yields.

6. To act as a way of condensing and presenting data in a manner which is simple to understand.

Using visual aids in the survey. The visual aids which are appropriate are of many kinds and, in general, are those in the list given in connexion with water-supply. It may be useful to add a few comments to that list.

Models. The building of a model to scale of a large area is an exacting task, and its results, in terms of gains in understanding, may not be worth the labour involved. The chief appeal of the model in local studies made in schools in England has been as a central 'show-piece' in an exhibition open to parents. This doubtless has its value, but it might have been as useful, in educational terms, to do something far less elaborate with a sand tray.

Maps. Maps are useful and important. The scale will depend upon the area studied. In general, use the largest scale possible. Remember that maps can be enlarged with the episcope and traced with the aid of the tracing table.

Pupils should collect data by field work—for example, details of land utilization, kinds of soil, areas liable to flooding. They should have rough maps and notebooks for field work and enter their data upon the master map afterwards.

Overlay methods, the use of mixed scales and other devices will be found useful. Standardize the various symbols and colours.

Make certain that everybody knows what he is doing, why he is doing it and how it is to be done.

Graphs. The real importance of the graph in this kind of work lies in its preparation. Merely to copy graphs from books and administrative reports is not enough. Pupils should collect statistical data from original sources and then design and draw graphs to make this data more easily comprehensible to themselves, their fellows and the public—if they propose to hold an exhibition.

While algebraical graphs are most appropriate in some ways, do not hesitate to use pictorial graphs because quantitative presentation is not always essential.

Pictures. For local survey work, especially in the East, it may be essential to produce all the necessary pictures oneself. Economy will limit the use of photography, but it should not preclude the use of pictures because these can be made by the pupils as pencil drawings, paintings and so on.

Those to whom work of this kind is unfamiliar may well think that it is too informal and not sufficiently academic in type. Much of its value lies in just these things. This new approach arouses interest, stimulates a creative response and helps the child to identify himself with his subject-matter. All these are important as elements in socialization. The exhibition too may be more important in the East than the West because it brings parents into the school and plays a part in adult education.

Visualization in History

While emphasizing the growing importance of social studies we must not deny a place to history in education—and here too there is a place for the visual approach. There are many films which reconstruct historic events and give them greater significance by dramatization—but the teacher who has no projector, or to whom such films are not available, can still use other means of helping his pupils.

Reference has already been made to time-charts elsewhere, and we may here consider one or two further points. A time-chart does not merely put into chronological order the events in one country—it should in some way relate these events to those taking place in other countries. Nor should it be concerned with events inside one country but with the contacts of in-coming and outgoing type.

Pictorial charts of the history of houses, the rise and spread of Buddhism, the history of costume, travel and so on should be explored and exploited.

Models have an obvious place in history teaching; the village, the fort, the temple, the church, all provide opportunity to learn by doing.

Dramatization must not be forgotten. At its simplest it is merely acting while reading from the book—at the other end of the scale it may be a richly reconstructed pageant or play. There is an experience to be gained from 'playing the part' which is too seldom made available to the student of history, and which is only now beginning to be appreciated as a result of psychological studies of role-playing. This experience we must use if we believe that history aims not merely at intellectual understanding but also at the identification of the self with the nation and at a readiness to see the individual as dedicated to the service of the people, whose present reflects the past and affects the future.

VI

VISUAL METHODS AND THE TEACHING OF LANGUAGE AND LITERATURE

THE USE OF VISUAL AIDS in connexion with the processes of language and the communication of ideas has a long history. It began perhaps with those murals and carvings which primitive man left behind upon cave walls, and it led slowly from pure representationalism to the elementary symbolism of pictograph and the more complex hieroglyph. It is not our purpose to follow this interesting development. It is mentioned in order to emphasize the point that language and picture, the verbal and the visual, are not so widely separated as our common practices suggest. Moreover it is still true that, if there is any 'universal language', it resides in the visual image rather than the verbal sound.

This remote historical connexion between verbal and visual is taken, by those who see child development as a form of recapitulation, as suggesting that in the early stages of mastering language use should be made of the visual approach. As a result we see our primers of reading illustrated with pictures of things. Children are expected to learn by linking together the visual picture, the visual symbols (letters of the word) and the verbal sound.

We cannot here enter into the basic problems of learning to read and write in any but the most elementary fashion. This is a complex field of study in which many developments have taken place in the West which should have a relevance for the East. All that we can do is to suggest some of the points which are worth attention. Even then it is really only possible to make suggestions, because little research has been done on the application of visual aids to linguistics and none of it appears to relate to the East.

Language teaching in the East is characterized, to a very great extent, by being formal, abstract and based on memory and drill. Its social setting is neglected, the importance of experiences which have meaning for the child are overlooked and the interest factor is almost absent. Visual aids should be used in language teaching and in relation to literature to make up these deficiencies as far as possible.

A word which is merely seen as a set of symbols can only be remembered; if a picture is attached there is a chance that it may be understood; if experience can be added there is hope that it may become a part of a functional vocabulary. It is to meet these needs that we must use visual aids as far as we can. It is true that children must learn symbols in order to read and write, but the common fault has been to attempt these too early and by wrong methods. In the hope of accelerating learning use is made of cut-out letter shapes, of templates for feeling and tracing and of letter blocks and other devices. The basic fault lies in the fact that the children using these things, though they may learn to remember, are too immature to understand. When the ability to understand is achieved the child is ready to learn to read and can then learn by the processes of thought instead of through sensorial memorization. At base S is not a shape, not a remembered movement, but a sound—written on paper, instead of made with the mouth. Words are not marks whose shapes have to be learned but the stimulus signs for things and ideas—which have to be experienced.

Our use of visual aids in this field should be to enrich experience, to give something of interest about which children want to talk, write and read. How can we set about this?

One field to explore would be the making of new books for language learning in which illustrations are numerous and simple, and in which they deal not with a jumble of isolated things but with an ordered sequence of events about which the child can talk. The drawings would need to be simple and stylized, and their subjects must come from the everyday life of the child: his family, his home, what people do in houses, the events of everyday life, the scene at the well, in the paddy field and the village street. These are the things of the Eastern child's world—not the stories, rhymes and pictures of the Western world in somebody's Reader, Book One!

Only after much talk of this kind, much seeking for experience, should we begin on the tasks of learning to read and write. To start too soon is to ignore the process of maturation and to stifle interest and effort in the disappointments of failure. When learning to read and write is begun it should be by modern methods—now described in many books—and with every possible visual aid. Thus the time relations involved in the words *past, present* and *future* can be illustrated visually in relation to the common ideas of *yesterday, today* and *tomorrow,* as in Fig. 15.

Some teachers have made such an apparatus as is shown in Fig. 16, which is an octagonal prism of four pieces which revolve on a central axis. Eight suitable sentences of four words each are printed on the eight faces of the prism. By revolving the pieces in relation to each other a series of new sentences can be constructed.

An action can be illustrated by a single picture, but better still by a series of pictures in which the static is replaced by a sequence to suggest movement. 'To run'

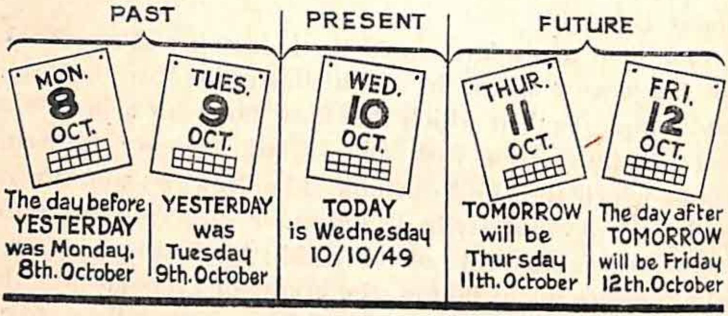
PAST
PRESENT
FUTURE
MON. 8 OCT.
TUES. 9 OCT.
WED. 10 OCT.
THUR. 11 OCT.
FRI. 12 OCT.
The day before YESTERDAY was Monday, 8th. October
YESTERDAY was Tuesday 9th. October
TODAY is Wednesday 10/10/49
TOMORROW will be Thursday 11th. October
The day after TOMORROW will be Friday 12th. October

Fig. 15. A simple way of showing time relations of past, present and future.

cannot be illustrated completely by a picture of a boy running–because he stays in one place in the picture! A

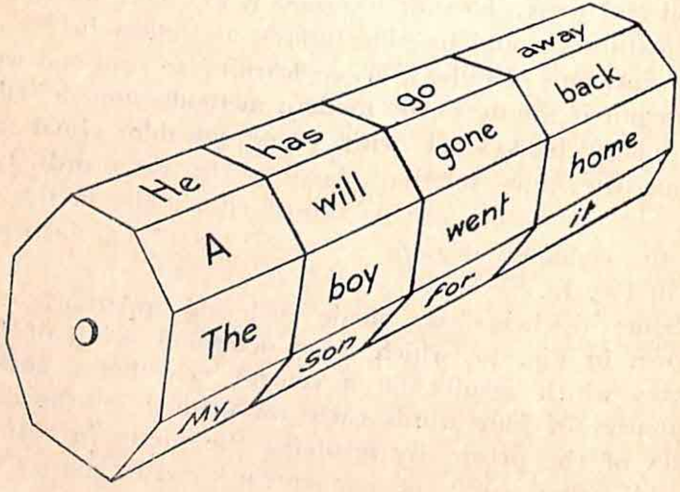

Fig. 16. A 'sentena cylinder'.

series of pictures, though each is static, can at least show that he has left one place and come to another. While the relation between symbols and meaning may indeed be a matter for the philosopher it is nevertheless a very practical problem to pupil and teacher. For the benefit of the pupil the teacher must use visual aids in those ways most likely to enrich experience and extend meaning. Two points to be taken as direct aims in this setting are to give meaning by showing action and to widen meaning by illustrating ideas which may stimulate imagery and thought.

While there are many accepted principles in relation to the mechanics of teaching the early stages of reading and writing, we have little to guide us in deciding how to use visual aids in either early or later stages. Moreover, if we lack guides on the mechanical aspects, still more do we in relation to the more abstract aspects of these important skills. However, it is possible to make some suggestions worth trying.

Our example of the use of several pictures to illustrate the meaning of ' to run ' may be the starting point for other ideas of this kind applied to other words. Another aspect is connected with words which are spelled differently but which have the same sound—a particularly common and trying feature of the English language which perhaps is also present in Oriental languages. Take the example ' their ' and ' there ' which is a common pitfall. Apart from the usual explanations and drill on this, and in addition to reading and writing as ways of learning this difference, we might try a visual approach. We could have two pictures, each to illustrate one of the following sentences : ' My hat is over there ' and ' Their hats are here '. This device is often used and the sentences are printed below the pictures. We might also try what was widely used by the American Services, the 'flap technique'. In this the operative word of the sentence is covered by a plain flap folded down over it. The learner is provided with words printed on separate small cards; from these he has to choose the one he thinks to be appropriate. Having done so he checks his choice by turning the flap up.

As skill increases we ask children to write sentences or compositions about some simple topic. The resultant work shows faults amongst which 'lack of ideas' is not uncommon. Of this we are critical in various ways, but what we seldom seem to realize is that the only way to improve the situation is to provide the experiences which must be the raw materials of ideas. We ought to ask children to write about what they have experienced—and our first step should be to provide those experiences. This is the aim of project work and activity methods in teaching, and of course of dramatic work, which we shall consider later. What we note here is that the visual approach, especially with the motion picture film, can provide vicarious experience. There is a great need for simple educational films which show a record of simple events of interest to children, events with which they can readily identify themselves and so gain experience indirectly, enrich their imagery and finally have something to write about.

The production of such visual materials is in its infancy. There are many films for children to see, some for young children, but few of them deal with simple topics which offer the chance of self-identification. In England we have films about natural history, how people work, about places and people; most of them are good films and all have their uses. Few, however, let the child feel that he is part of the event, not because they lack interest for children, but because they do not include children or a child with whom the viewers of the film can identify themselves. (This of course is bound up with legal problems of child employment into which we cannot enter here.)

While suggesting that pictorial materials can stimulate imaginative response it must not be overlooked that this has not yet been demonstrated by research. Indeed, it is maintained by some investigators that such a claim is not true. It is probable that a more acceptable verdict would be 'not proven', because such investigations as have been made have been of a preliminary survey type and have not altogether overcome the difficult task of objectively rating or measuring imaginative content and increases of skill in composition. Until this is done we can continue to believe that enriched experience contributes to a fuller mental life.

One important aspect of this fuller mental life is in terms of interests. We know from experience, without the need of any kind of elaborate testing, that interest begets effort. The boy who, in an English school, makes little effort at algebra or history will work with passionate intensity at collecting fossils or studying trains. He would explain this by saying that 'algebra is dull—trains are interesting'. What can we, as teachers, do to transfer interest to, develop interest in, school subjects?

Although we have many studies of children's interests they have been carried out in the West more than in the East and the results obtained are not always in agreement with each other. The relation between interest and effort, however, is undisputed. Another aspect, of considerable importance, is that of the origin of interests. Does the stimulus come from the ordinary commonplace events of every day or from what is novel and strange? Again we should notice the relation between interest and meaning—and here perhaps lies the key to our use of visual aids in connexion with language. Words have meaning which is ultimately bound up with a situation of events, things, people and ideas. It is because of this that, even to express the same idea, we use one word under one set of circumstances and another word in another situation. To put it in another way, words are used in terms of a social, emotional or other situation. In all reading matter the context obviously gives us a key to this situation. Our pupils, however, are beginners; they not only have to struggle over a particular word, but perhaps also with the words of the context. Visual aids can help us by giving meaning to the situation in pictorial terms.

The teacher who wishes to use the visual approach to language teaching, whether in terms of mechanics of reading and writing or in terms of comprehension and appreciation, can be assured that much exists which will help him. His start can be a very simple one, that of collecting pictures from magazines and so on which illustrate things and ideas and which can be used as a basis for oral work. Language began verbally—by talking. To introduce writing and reading too soon is to ignore the implications of biological history. While the provision of pictorial material is suggested as a starting point it must not finish here; the habit can well be carried right on throughout school life.

When a start is made at reading and writing there are available all the materials so well known to primary school teachers in England. Letter cards, flash cards with words, pictures and so on. Small cards with letters can be bought, but many, perhaps most, teachers make their own. Cards with words are also necessary together with pictures. Any beginner's reading book contains letters, words and pictures. In the East, however, the print is usually far too small and the pictures too few; this the visual-minded teacher can overcome by his own effort. It should also be remembered that the school has older pupils who can help to produce teaching materials–an activity which can be part of art or craftwork and which gives exercise in using skills, contributes to a sense of importance and achievement and is a valuable social co-operative experience.

Word cards, or flash cards as they are often called, are used for matching and sentence-making. In the early stages a child has a set of pictures and flash cards and pairs them up. Later the purpose is not merely to identify an object, but to make a sentence about it. It may be found convenient to use lettering of different colours for words of different kinds, such as red for verbs and green for nouns. A variant on the method is to use the flap technique mentioned earlier. Thus we may have a picture with a bullock running. At the bottom is a printed sentence–'The bullock is running'. The last word, 'running', is hidden by a flap. The child has to find the word among his flash cards and check his decision by lifting the flap. Another device consists of pieces of card cut and stuck together to form a grooved channel into which single letters can slide. One letter is put in and others added to build a word–this is of course possible with the loose letter cards, but the grooved letter-holder gives a greater sense of permanence. Devices of this kind have proved their worth in the West and will doubtless be equally useful in the East though the different scripts will present new problems.

Filmstrips and films are available which deal with lettering, handwriting, the history of handwriting and printing. These may make a direct contribution to learning these basic skills–in addition they contribute in terms of interest.

In the teaching of foreign languages it is often found difficult to demonstrate the position of the tongue, lips and so on. Here is a field to be explored photographically by film and still camera. A start has been made on this in the West.

Language is a part of culture and language teaching; instead of being merely the learning of grammar and syntax, it should contribute to intercultural understanding. For this reason we should make use of background films and other visual material. The child learning English should see something of the English way of life: the people at work and play, the country, its towns, buildings, and how people live in it. Literature has its setting not merely in the minds of men but in the physical environment of living which has so often stimulated mental and emotional reaction. A proper appreciation of literature necessitates an understanding of and feeling for the physical setting from which it sprang. What is there in lowland paddy scenes to act as a background for reading some of Wordsworth's lake poetry? The same argument holds good with other writers.

To sum up the situation one may say something of this sort. Visual methods have been applied to language teaching in its early stages with younger children in the West and the methods employed, which are described in many books on language teaching, could well be used in the East. For older children the visual approach offers most in terms of the stimulation of interests and the enrichment of cultural understanding. The teacher can do much here by collecting pictorial materials or by using the films which are available. Most of these have been prepared in regard to Western languages. It should also be noted that there are simplified language books in which a minimal amount of verbal material is supplemented by schematic diagram-type drawings. Despite their value in teaching adults it is doubtful if they have a very important part to play in the school because, however efficient they are in terms of the mechanics of language control, they have little to contribute to cultural understanding and appreciation.

Finally it may be noted that far too few language teachers have a clear understanding of the language and of the way in which 'meaning' is built up from a series of factors such as the sight (appearance) of a word when printed, its sound when spoken, the acts involved in using the word, and the object the word represents. It is necessary not only for the teacher to appreciate these relationships, but to discuss them with senior pupils specializing

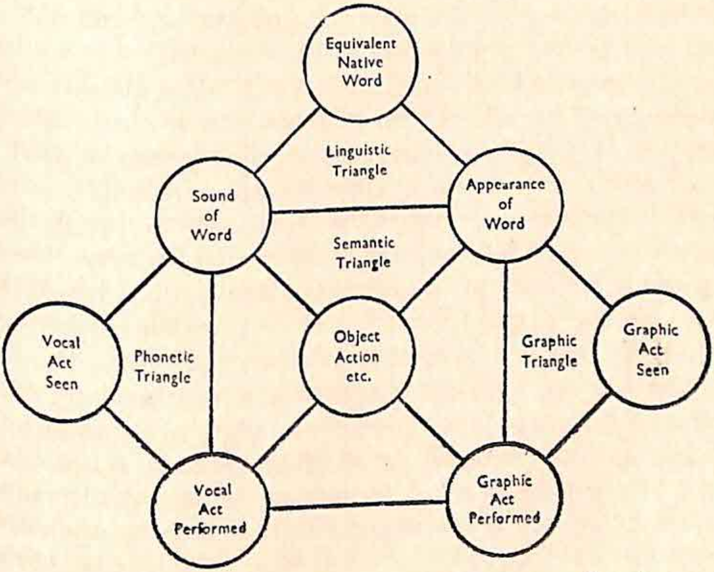

Fig. 17. Diagrammatic relations of the sight, sound, action and meaning of a word. (By courtesy of Mr W. L. Sumner and Messrs Blackwell after an original by Professor Patrick Meredith.)

in language study at sixth form level. In order to help pupils to understand the complex relations involved use can be made of a diagram such as is shown in Fig. 17.

VII

VISUAL METHODS AND THE SOCIALIZATION OF THE CHILD

EDUCATION TODAY is characterized by a number of attitudes which, if not new to the world of educational theory, are at least novel in the sphere of educational practice. The great leaders of educational thought in the West have always had before them the concept of education as a process of socialization. While the writer would hesitate to make so definite a statement in relation to the East, his reading (of translations) and his conversations with Oriental scholars lead him to believe that the same condition holds here and moreover, has been characteristic of educational thought here for a very long period.

It is in our educational procedures that we have gone wrong. Education has become a process of instruction with a single aim, that of passing examinations. The examination, at one level or another, has been the essential prerequisite even for getting on to the first rungs of the ladder which it is hoped will lead to success. No one will deny that examinations have a place in education, but everyone should deny that they are the whole of education. In India and Ceylon, with growing populations and a fundamentally rural economy, with a social structure still deeply influenced by caste, status and the dowry system, and with a comparatively limited field of occupational choice, there is fierce competition for employment. The greatest demand is for 'white collar jobs', for thus, and thus only, can the individual hope to raise his occupational status. Entry into the clerical and related services demands, at the least, a school certificate and to acquire this means of escape from a life of abject poverty has become the great ambition of parents and children. Growing up within the framework of this competition and always aware of the clamour by parents for their children's success in examinations, teachers have taken these as the only criteria of their own success. The proportion of graduate teachers is low because other professions are financially more attractive. The vast majority of teachers have minimal qualifications and far too few of them have received any professional training. In such a situation, backed by a long tradition of oral teaching, education has become academic and formal. The emphasis has been on instruction and remembering, not upon experiencing and doing. Interest, enthusiasm, creativeness, appreciation—all that is so important in the development of personality and character has been forgotten.

Much of this has been true of the West, but a change has come about. The cumulative effects of widespread, freely available education, the decay of feudal and privileged society, the rise and spread of democratic ideals and the sociological effects of two global wars have turned men's thoughts to the education of boys and girls as the future men and women, not only as candidates for certificates. The West has begun to act in the belief of so many of the past leaders of social reform—that 'education is social philosophy in action'. Education must make people, not candidates. It must not only make pupils fit members of society, it must also make a society fit to live in.

If these things are true of the West then they must also be true of the East. The newly emergent dominions seeking to build new worlds of democracy need men and women of vision, integrity and courage, people who aim at high ideals and who will shoulder the responsibilities which fall to all who seek new 'rights'. An education based on the examination syllabus, putting the emphasis on instruction, built up on authoritarianism and ignoring all the qualities of human spirit and personality will not contribute to these new worlds. Education must be socialized in order that we may socialize the individual.

Here in the East child-rearing practices in home and school are inhibitory, traditional and restrictive as compared with those of the West. In particular they operate to limit the experiences and freedom of the individual and in doing so they are making it difficult, if not impossible, for society to be remodelled. Education, and education alone, is the one social force which can reconstruct society. This point of view has been accepted in the West—and hence the emphasis on learning by doing, learning by experience. Education has changed in its aims, its content and its methods; it has become a process of socialization.

The process of socialization depends upon experience. Just as man today has been conditioned by the past, so man in the future will depend upon the socializing experiences of the child of today. Our task, as teachers, is to guide development by controlling experience. Modern man is the product, as it were, of all past history. In trying to reconstruct the society of the future, while we may not want to call upon all past history, at least we feel the need to call upon worldwide experience today. Living in a restricted environment, hampered by lack of opportunity to seek varied experiences and always pressed by lack of time, we naturally seek to exploit every means which will widen the range of experience open to our children. One such means is the film with which we can provide experience in vicarious terms. All who have seen the best that the film can do are aware of its power of building up the illusion of reality. While watching a film we are no longer mere spectators, but we identify ourselves with one of its characters. For a time we live a new life in a new world, and may even find it difficult to come back to reality! It is through this vicarious experience that the film changes the attitudes of people, not only temporarily but in long-range terms. And because it can change attitudes it can be a potent factor in the process of socialization. Children the world over are being influenced by the film, just as adults are, and not always for the best. In the East the dangers of ill effects from the film are greater because so many of our films present a culture pattern which is both different and questionable. How to exert some control over the film, one of today's great sociological forces, is a complex problem into which we cannot go here. But at least we can give some attention to the use of the film, and of other visual media, as instruments of socialization in education.

One field which we can explore concerns the social relations of knowledge, the application of knowledge to social affairs. As soon as we want to make education something more than instruction we at once become concerned with this new and wider aspect. We want to study biology not merely to pass an examination, not merely to learn about plants and animals, but also in order to understand human life more completely. It is true that we try to do this in school by various means: for example, in physiology and hygiene, in home science, and by direct reference in biology lessons. But we are limited by many factors, by the complexity of the subject, the immaturity of our pupils and by the difficulties of demonstration. Here the film can be of great help. With it we can show how population changes necessitate new levels of food production and how these depend upon chemistry, agriculture and biology. The film can show how industry uses the principles we study in the chemistry or physics lesson in the service of man. We could use the film to build up new attitudes towards hygiene in the home in relation to water, cleanliness, food habits and the like. Indeed this field of health education may well prove to be one of the most appropriate for the use of the film and filmstrip.

Culture, too, can be dealt with visually. The presentation of indigenous cultures depends upon many factors, not the least of which is appreciation. To many of us our cultural surroundings have become merely commonplace. They raise no thrill of enthusiasm, no sense of creation, nor satisfaction, no happiness in the fitness of form and function. The craftsman struggles to earn a living in a world which is content with the poor design so often associated with the mass-produced. The people of today, under the pressure of 'modernization' have lost their sense of community with the past; even worse, they are often ashamed to admit that it could ever have been real. A nation which renounces its culture gives up its soul. Today, with the rising tide of national awareness in danger of ebbing before the standardizing influence of westernization, there is need to rebuild faith in domestic culture. One step towards this is to let people see their own culture and, as only a few can travel, we must do this by the pictorial means of visual aids. There is here a great field for exploration which can be dealt with by simple means, such as magazine illustrations, picture postcards and the like, as well as the more complex and expensive film and filmstrip.

If experience is to play a real part in socialization we must use our visual approach with discretion. We must provide direct as well as vicarious and indirect experience. One way to do this is to let our pupils take a part in the production of visual materials. Let them collect illustrations or make their own, arrange their pictures and write up the story. This will almost certainly involve group activities which will give experience in co-operation, planning and the acceptance of responsibility. Moreover, such work will bring the teacher and pupil together in a new and more informal relationship which in itself is an important factor in socialization.

Where visual materials are made in the school, however humble their character, they should have as much local reference as possible. The smallest village shows social problems which are not entirely different from those of the town. The evidence of past history is to be seen in the countryside as well as the city. This reference to the locality carries the conviction of reality, it helps to make the child feel that he is part of a larger world, gives him a new degree of social awareness which is part of socialization.

This linking of the child with the locality around him must be followed by the further step of building up awareness of his relationship with the rest of his people—with his own country. It is when we turn to this, and other larger aspects of socialization that we appreciate more fully the value of the visual approach. Pictures, filmstrip and film can introduce the town and country children to each other and can show that, although people of plain and upland look different and live differently, they are faced with many common problems. All who are aware of the conflicts which exist between town and village, upland and lowland, even between the north and south in India, should be ready to use every means possible to replace these conflicts by a new degree of mutual understanding.

From the communal problem it is but a step to the international problem; the ability of visual aids to 'bring the world to the classroom' offers a potent aid towards developing world understanding.

The topics discussed in this chapter are of such importance as to demand the greatest possible degree of attention, and so varied as to offer almost unlimited opportunity for visual presentation at every level. Among the simpler techniques there are those which will be referred to in Chapter X, such as time-scales, process diagrams, sector diagrams, population diagrams and social base maps. Apart from these there are somewhat more

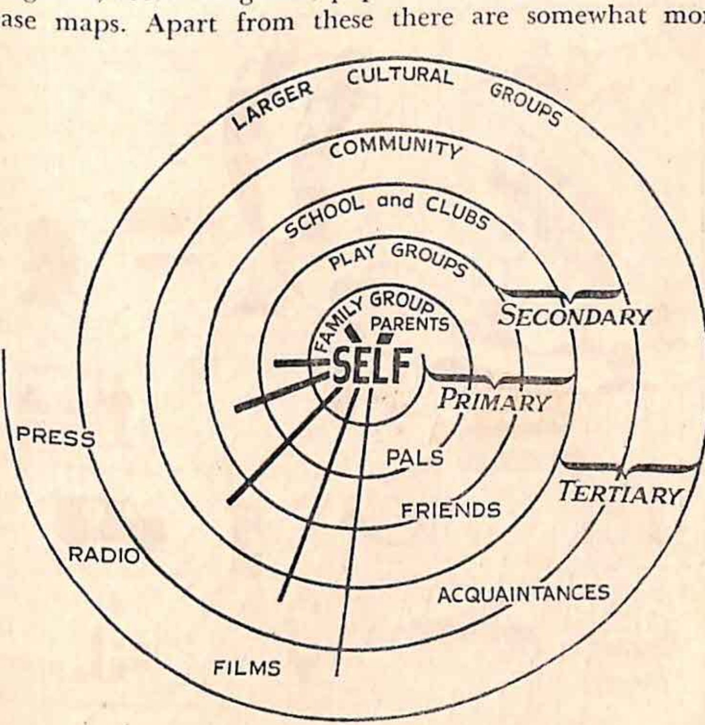

Fig. 18. A spiral diagram to illustrate the self and its widening fields of psychological and social contact.

complicated procedures of which three examples are given. Fig. 18 shows how a spiral diagram can be used to illustrate a process in which a central unit (in this case the 'self'—the individual child) comes into ever wider contact with the social agencies of the environment. There is no attempt at 'scale' in such figures, neither is there any attempt precisely to limit any one zone or area, for the essence of such a situation is its fluidity. Some kind of differentiation can, however, be obtained by labelling, by a broad zoning and by the use of radial lines. By drawing

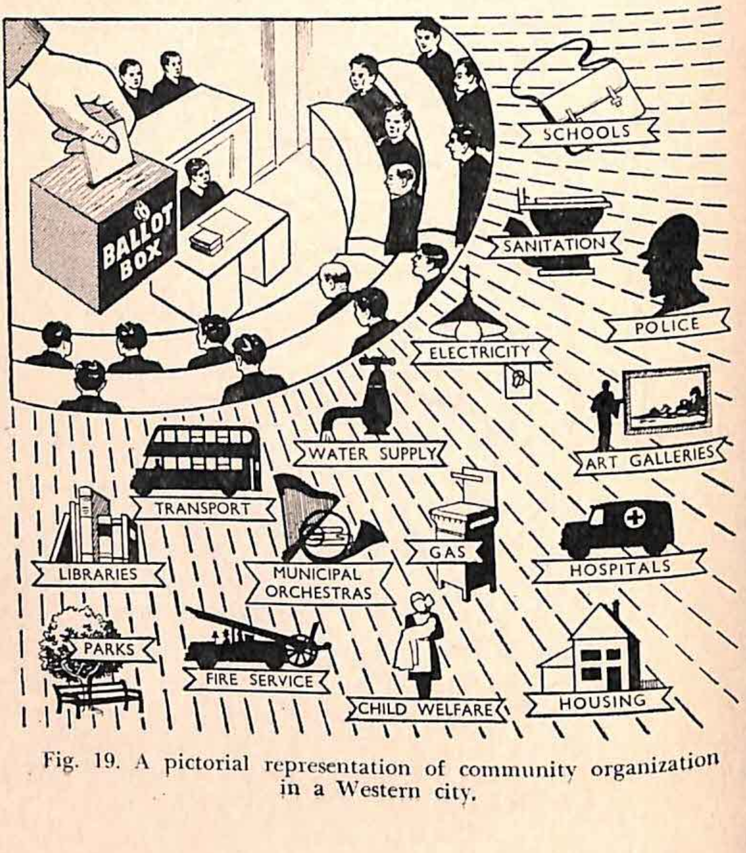

Fig. 19. A pictorial representation of community organization in a Western city.

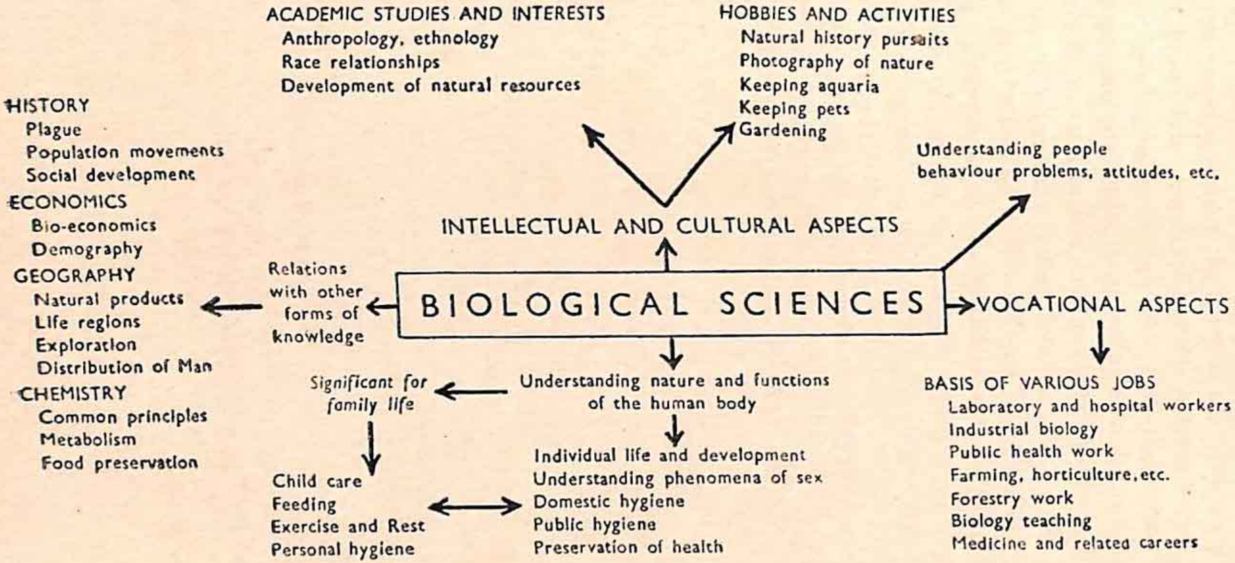

Fig. 20. The social and academic relations of the biological sciences.

these radii of different degrees of thickness closer relationships can be suggested with thick lines, and less intimate relations with thin lines. Figure 19 shows how a semi-pictorial approach can be used to illustrate one aspect of the complex web of community relationships and to focus attention on the idea of individual responsibility—for the whole set-up is linked to the individual by virtue of the vote. Using this as a model it would be a valuable exercise for any group, whether children or adults, to prepare a similar diagram for their own group, school, village or town. Figure 20 is also concerned with the problem of relationships, in this case those of a school subject, in order to show how different forms of knowledge are related to each other, to the individual and to the community.

VIII

STORAGE AND PRESENTATION OF VISUAL AIDS

In order that visual materials shall be aids and not annoying nuisances to normal classroom procedure it is important that some care should be given to the question of storage and presentation. One very important point is to decide how far the visual aid service within the school shall be centralized and under the control of a single teacher. There are many disadvantages to this system—but it often increases the use of these materials because unless one person is responsible other members of the staff feel that 'it isn't their job'. As far as possible everyone should use visual materials, which means that every member of the staff should be acquainted with the methods of visual approach.

In the East, where visual methods in teaching are, so far, poorly developed it may be preferable to start with a centralized service in the charge of a single individual. He should be competent at as many aspects of the work as possible and it should be his job to help others to become competent and to inform them of developments in the service. The duties required of him can be put under the following headings:

1. He must be aware of developments in the visual field through magazines and catalogues and must circulate information to those interested.

2. He must have a comprehensive, easily used file to show what materials are available in the school.

3. He must keep a reliable record of material lent

out from the central collection and check its condition on return.

4. He must be able to train and advise others in all aspects of visual education.

To ensure that visual aids are used with maximum effect it will be necessary to deal with a number of points of practical procedure on which brief notes are given below. It must be emphasized that these notes are written with school conditions—of a special kind—in mind. In a museum or in a school with well-developed technical and clerical resources these simple methods would be replaced by more advanced and more complex methods which would be out of place here.

Cataloguing Visual Materials

All materials should be catalogued. Standard 5″ × 3″ (125 × 75mm) library cards are convenient for this purpose. When working on a large scale it is useful to have cards of different colours which could be used as follows:

Red cards: motion picture material. Each card to be marked Sd (=sound) or Si (=silent)

Blue cards: filmstrips, miniature slides, lantern slides, micro-slides.

Green cards: materials for episcopic projection.

Yellow cards: models and specimens.

White cards: wall charts and diagrams.

The catalogue must be cross-referenced and can consist of two series, one arranged under subjects and the other under materials. A card in the subject series might be as shown in Fig. 21.

From this card we can see at once that several kinds of visual materials are available. By turning to the cards

EVOLUTION

SUBJECTS	
Palæontology	Local fossils (specimens): Museum Prehistoric animals (models): Museum Filmstrips B.E. 3, 14, 27, 28 Postcards: Museum Charts (Time): WCH A 1-3 Flints: Museum
Compar. Anat.	Drawings: Sets E.e., EA, F/Strips B.E. 30, 34, 35
Systematics	Evol. tree: WCH EC I. Evol. of Man: WCH EM 1-2
Embryology	Drawings: Set E.e. Photos: PE 1-7 Slides: Boxes 22-25
Distribution	Maps: Sets M. A-F

Fig. 21. Layout of catalogue card with data of subjects.

classified under materials we can find details of these materials as shown in the examples of Fig. 22.

More elaborate and better filing systems can of course be devised, but this will be found quite effective. A filing system should be started at once and grow with the growth of the visual aids materials. If it is delayed 'until there's enough to be worth cataloguing' it will probably never get done.

Loaning Materials

As the collection grows and is used by more and more people on the staff the need to keep a record of who has what will become more evident. In reality this need exists from the beginning and a system of recording loans should start then—not later, when much material will probably have been misplaced and lost. All methods of recording loans, especially those where there is no ever-present custodian, depend upon the integrity and conscientiousness of borrowers—characteristics which, as we all know, seem to be poorly developed!

EVOLUTION

MATERIALS

Pictorial	Wall charts : WCH 1-3, EC 1, EM 1-2, Photos : PE 1-7. Museum sets. Local. National E 1-7 Drawings : Set E.e., EA	
Models	Prehistoric animals : School museum. Local museum.	
Wall charts	Geological periods:	WCH A 1-3
	Evol. tree :	WCH EC 1
	Evol. of Man :	WCH EM 1-2
	Maps—distribution :	Sets M. A-F
Filmstrips	Prehistoric animals :	B.E. 3, 14, 27, 28
	Compar. Anat. :	B.E. 30, 34, 35
Specimens	Fossils : Carbonif., Jurassic, Cretaceous (Mus.)	
	Slides : Boxes 22-25	
	Flints : Museum	

Fig. 22. Layout of catalogue card to show materials available to illustrate various subjects.

The simplest method to use is to provide every borrower with a set of borrower's cards carrying their names. When a visual aid is borrowed the borrower's card is clipped to the index card for this particular visual aid in the index file of classified materials. On returning what he has borrowed the borrower removes his card.

Filing and Storing Visual Materials

Effective filing and storage is essential, otherwise materials cannot be found when required and are liable to be damaged by being left about unprotected. The methods to be adopted depend upon the materials and in some cases will also be related to the method of presentation of the materials.

Films. All films should be wound on spools and stored in cans. In tropical conditions films tend to take up water from the air and to become infected with fungus. They should therefore be cleaned by wiping with a soft cloth damped with carbon tetrachloride or tetrachloroethylene and kept in a place which is as dry as possible. Thus the tins can be put into a large box containing a drying agent but not enough to cause brittleness.

Most of the damage to films is done by faulty handling. Avoid dust, oil, handling the film surface, imperfect mechanisms and allowing the film to trail on the floor.

Filmstrips are usually bought in a metal or cardboard container which can be used for storage. The precautions used for film can be applied to strips. A letter, number or some other code symbol should be legibly printed on the top of each container. These must be stored in some convenient way, such as in a cabinet of shallow drawers. Each drawer should be subdivided by a series of parallel vertical strips just far enough apart to accommodate the strip containers. To subdivide each drawer into a series of square cells, or to use some system based on circular holes, one for each container, involves more work and wastes space.

Slides. Whether standard-size or miniature slides are used, they should be stored in suitable boxes. These can be made of plywood to a design such as is shown in Fig. 23. The front is lower than the sides to enable the slides to be removed easily. The gap is closed by the strip along the front edge of the lid. For standard English slides the internal measurements should be 3-3/8″ × 3-3/8″ (85 × 85mm); for miniature slides make it 2-1/8″ × 2-1/8″ (54 × 54mm). The length should be suited to the number of slides it is desired to store. The plywood should be given a coat of casein or marine glue and then varnished. The use of slots to hold the slides vertical has many advantages but means more work and reduces the number which can be held in a given box.

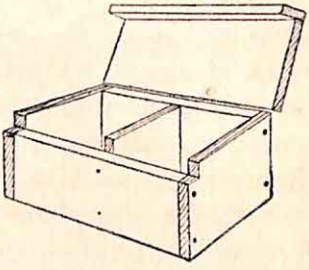

Fig. 23. Design for a wooden slide box.

Episcope materials. The frame or aperture of the episcope limits the size of the picture which can be used, in most cases to about 5″ × 5″ (125 × 125mm). For this reason one must collect materials which approximate to this size. These materials are most likely to consist of: (*a*) picture postcards; (*b*) pictorial materials cut from magazines etc.; (*c*) specially prepared materials.

Picture postcards are nearly all of the standard size of 5″ × 3½″ (125 × 88mm) and can be conveniently stored in envelopes. Each envelope can be devoted to a particular subject, the details written on the outside and the envelopes stored in a suitable box. The other two types of material can be mounted on thin cards cut to a standard size of 5″ × 5″ (125 × 125mm) or 6″ × 6″ (150 × 150mm).

Some teachers have experimented with 'episcope rolls' —sets of pictures arranged in order and glued to a long strip of cloth which can be fed through the machine by hand or arranged to run from one roller to another. It appears doubtful whether the effort involved is worth the gain.

Large-sized visual materials. Many of the visual materials we use are large posters, pictures cut from illustrated magazines and so on. They also vary in size. Both features present certain difficulties which must be met as seems most appropriate. Experience suggests that greater ease of filing, storage and using, together with a longer life, are achieved where all materials are treated in a standard manner. The writer has found that the simplest of the many which could be adopted is to use these materials to build up wall charts or broadsheets by pasting them on stout brown paper. A convenient size is one which will accommodate a double-paged illustration from such magazines as *Life, Picture Post* and the *Illustrated Weekly of India.* A single topic may be dealt with on a single sheet or have several sheets devoted to it. Such sheets can be used for individual examination or for communal viewing, and in any case the questions of storage and display arise. The following can be considered.

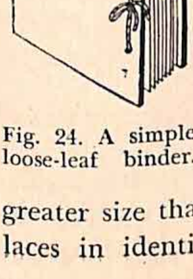

Fig. 24. A simple loose-leaf binder.

Loose-leaf binders. Take two pieces of stiff cardboard or thin plywood of slightly greater size than the mounting sheets. Drill two holes for laces in identical positions near the long edge of each board. Reinforce the edges of the mounting sheets at these places and punch holes through. Lace up the sheets in the covers. (See Fig. 24.)

Folders. Make a folder from cardboard or heavy paper with a gusset pocket. File the mounting sheets in this. (See Fig. 25.)

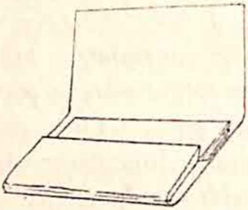

Fig. 25. A simple folder made from thin card or heavy paper.

'Clip-back' filing. Cut two strips of thin wood of the same length as the long edge of the mounting sheets Arrange a series of these sheets in suitable order. Place them between the wooden strips and screw these together with short brass screws. Bore two small holes in a suitable position and lace string through to hang the file on the wall (see Fig. 26). A strong 'bull dog' paper clip should

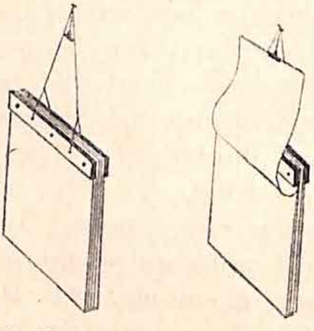

Fig. 26. A simple clip-back file for wall use.

hang from the nail to hold sheets which have been folded up to disclose those lying below.

Display of Wall Sheets

All those sheets which are to be hung for communal viewing should have the four corners strengthened by gluing a fold of paper over them (see Fig. 27). When dry, punch a hole through. When hanging the sheet up put the drawing pins through the holes and press home until the head of the pin clips the sheet down. Greater strengthening is achieved with the aid of a metal eyelet punch which inserts aluminium eyelets into the paper.

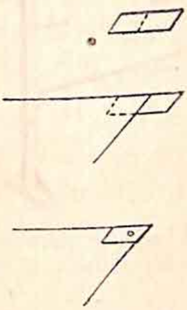

Fig. 27. Strengthening the corners of wall sheets.

Wall sheets can be pinned to the wall or a blackboard, but it is preferable to make some special provision. The simplest of all is to use long strips of wood which are screwed to the wall. If all the sheets of visual materials are arranged either vertically or horizontally only two strips of wood are needed. If it is desired to hang some vertically and others horizontally then three strips are required. The distances between the strips depend upon the length and breadth of the paper sheets, while the length of the strips depends upon the wall space available. It should be remembered that the display is for children ; do not hang the pictures too high.

Portable Display Methods

It is sometimes necessary to be able to move exhibition material about from room to room in the school or to send it round from school to school. The former requirement will be met if each room has wooden battens on the wall so that the pictures can be easily re-hung. An alternative is to make one or two light portable stands which can be carried from room to room. A suitable design is shown in Fig. 28, which makes use of strips of wood and thus involves less cost than the use of plywood panels. Use wooden strips 2″ × 1″ (50 × 25mm) in section for the frame and use triangular plywood pieces to give extra support to the upright pillars. The horizontal rails should be so spaced as to take a standard size of paper (e.g. Imperial) in both horizontal and vertical positions.

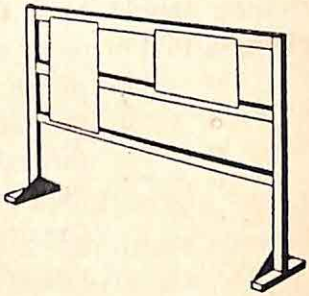

Fig. 28. A simple portable display stand.

The circulation of a loan collection between several schools always involves greater wear and tear, so greater care must be taken to ensure adequate protection. Experience suggests that a loan collection should be as small as possible so far as the number of items and their size is concerned. Moreover, it should be noted that it is far easier to handle sets of pictures mounted flat than to deal with collections which involve models and other solid objects.

Flat pictures, for a loan collection, should be pasted down carefully on standard-sized stout cardboard panels with eyelet or punched holes for the drawing pins. If possible each panel should be covered with a sheet of cellophane for protection. If this cannot be done it may be possible to paint each panel with colourless paper varnish which helps to give a hard surface resistant to dust and finger-prints. The complete set of cards should be put in a shallow box, or at least protected by plywood panels for transit purposes.

Solid materials, such as models and specimens, must be dealt with individually in small boxes made to fit them. For certain purposes, for example in geography, we may wish to circulate a set of maps, photographs and models—say, a relief model of a particular area. Here we could use a shallow box to serve both transit and display, showing how a set of materials can be used to make a contour model. It includes:

1. 1″ to 1 mile (or 25mm to 1·6km) ordnance survey map of selected area.
2. Tracing of contours only from this map.
3. Pieces of plywood board with contours traced on to them.
4. Some contour shapes cut out.
5. Complete set of contour shapes cut and assembled.
6. Contour models showing stages in 'working' the contour edges.
7. Finished model.
8. Oblique air photograph of the area concerned.
9. Vertical air photograph of the area.
10. Sets of ground photographs.

The value of such a set is increased if a series of photographs of the area is available, taken from the ground and from the air. Finally, the area should be visited and walked over.

The whole material is mounted in a series of flat plywood boards which slide into grooves in the container box. This box can be opened flat and stood on end to act as a display board for part of the material.

Visual Units

The example referred to above consisted of a set of materials all related to one topic. It might well have been supplemented by a film, some filmstrips and a booklet. Such a collection illustrates the obvious fact that certain ideas are complex and require explanatory treatment of several kinds. To such a demonstration the name 'visual unit' was first applied by Professor G. P. Meredith of the University of Leeds, England. The idea was subsequently taken up by the British Ministry of Education, which produced a number of such units. This term is now less often used but no other which is so conveniently descriptive has been suggested. All teachers who wish to develop the use of visual education in their schools should think along these comprehensive lines and should try to build up visual units on a series of the more important topics.

This does not mean that each visual unit must consist of a set of various materials, nor that every topic demands a visual unit. But it does suggest that we should do well to think in larger terms than the single filmstrip or film by itself. The reasons for this are many, most important of all being that we need to look at our topic in different ways and may well give different treatment to each aspect. The film is an excellent means of giving a generalized view aiming at orientation, a general survey to give a 'set' or to build up an attitude. With the filmstrip we can present details and give to them more minute study. With the model we can illustrate structural relationships, dependent perhaps upon the capacity to think in terms of three dimensions. Finally, with graphical and tabulated statistics we can present data of a very precise kind which can be made the basis of quantitative treatment.

Visual units, consisting of several kinds of materials, present the problem of whether each part should be stored with its own kind or whether the unit should be stored as a whole. It is far more convenient to use the latter method and the unit should be designed with this in mind from the start.

Individual and Group Work

Progressive teachers are paying more and more attention to individual work by their pupils and to communal work by small groups as opposed to 'class teaching'. If this move is to continue, as one hopes it will, it is essential to ensure that communal viewing does not force one back too completely to 'class teaching' situations. These must be used, but there must also be a place, and a big place, for work initiated and conducted by the pupils. If this is to be possible, two conditions must be fulfilled :

1. Much visual material must be available for reference and use by pupils—not neatly filed and locked away in a cupboard.
2. The raw materials must be ready at hand for pupils to make their own visual aids.

A few comments on each of these points may be helpful. First, it is not suggested that pupils should have the run of all visual materials, but that as much as possible should be readily available. The best way to deal with this is to have duplicate sets of some materials and small 'index collections' to represent, say, the larger visual units. In this way the main teaching collection will always be available and complete. Secondly, to allow and encourage pupils to make their own visual materials is not merely a good teaching device but also a 'teacher's help' in the sense that duplicate sets and the like can be made by pupils. The raw materials, a few hand tools, crayons, paints, and a small work-bench can be set aside for use when need arises.

A question which often arises concerns the use of projection apparatus by pupils. The answer seems to be to encourage it as much as possible, provided that safety precautions are adequate, first in terms of the pupils and secondly in terms of the apparatus. Any pupil who can learn to handle laboratory apparatus can learn to use a motion picture projector. The skill required to handle other forms of projection apparatus is still less. By being able to use these machines films can be seen more often and learning improved. The exercise of handling them has value in itself, and still more in its contribution to the development of a sense of responsibility and feeling of satisfaction. If education is ever to be more than instruction we must take every such opportunity which fosters these important attributes of the matured and balanced personality.

IX

TOOLS, MATERIALS AND METHODS IN MAKING VISUAL AIDS OF NON-PHOTOGRAPHIC TYPE

THE PURPOSE of this chapter is to suggest ways and means of making one's own visual aid materials without the aid of photography. While there are obvious limits to what can be done without photographic aids and without calling upon projection techniques, there is much which can be done. Even more important is the fact that in some schools lack of finances and equipment will prevent the use of photographic projected materials. For these schools—and there are many such, not only in the East—the only visual aids likely to be used on a larger scale are those which teachers and pupils can make for themselves. It is therefore essential to describe the more important tools, materials and methods which will be called upon in undertaking work of this kind. It should be noted that some overlapping between the contents of this and the two succeeding chapters is unavoidable.

Base Materials

The making of visual aids requires a variety of base materials on which to draw diagrams and paint pictures. The more important are:

Paper is an expensive item and one must therefore make use of anything obtainable. All kinds of waste paper, white and coloured, should be saved from all kinds of sources. When at last special purchasing is unavoidable the cheapest sources must be explored. Of these there are three to be specially noted. Kitchen paper (mostly used for lining drawers) is cheap and useful. Paper-hanger's backing paper is fairly cheap and useful. Newsprint, which can be bought as waste ends from incompletely used reels at newspaper printing offices, is extremely useful. It might also be noted that sheets of newspaper should be saved as they can be used for making papier mâché, and even for drawing bold diagrams. We who live in the West are used to obtaining paper with ease, which is not so in the East.

The advantages of buying special paper are that it is available in several standard sizes of varying thicknesses (or 'weights') and that various surfaces are available. Some are hard (i.e. hotpressed) and will take line drawings in ink, others are suitable for use with water-colour paints.

In making diagrams which are to be photographed, as in making a filmstrip, it is preferable to use paper which has the least possible glare and is as pure white as possible; any tinge of yellow should be particularly avoided.

Card. Professional illustrators prefer to work with stiff card rather than paper. When one need not bother about expense this is understandable because the card base will stand more 'working on' than a paper base. Card can be bought in various sizes and weights and with a variety of surfaces. Bristol-board is probably the best for line drawings in indian ink. Cartridge surface cards are good for water-colour work as they do not embarrass the amateur with so much wrinkling as paper does when a colour wash is attempted.

Cardboard is of great value to the model maker, and all kinds of boxes made of cardboard should be collected and stored. Cardboard is of various kinds of thicknesses:

millboard, straw-board and so on. Save as much as possible of all kinds, including corrugated cardboard.

Plywood. For many purposes plywood must be used because of its rigidity. For most model-making in visual aids 3-ply is sufficient, of 1/8″ or 3/16″ (3 or 5mm) thickness. It is rather expensive (about 50 np a square foot, or 50 cents in Ceylon), so adventitious and scrap materials (e.g. from old tea-chests) should be used. Most of the plywood made in the East is bonded with ordinary glue and will therefore not withstand water or high humidity for long. It can be made more resistant by painting it over (including all joined faces and edges) with two coats of marine or casein glue. Resin-bonded plywood is absolutely waterproof, but expensive and seldom available for the amateur.

Fibre-board. Various proprietary materials, usually consisting of sawdust bonded under pressure with a cellulose glue, are available and are excellent for model-making. Unfortunately they tend to be more expensive than plywood.

Drawing Instruments

It is not necessary to have an elaborate equipment of drawing instruments. As a basic set it is desirable to have a certain minimum, as shown below :

Pencils : soft and hard, e.g. 3B, B, HB, 2H.

Pens : mapping pens and handles for thin lines ; lettering pens, one handle and reservoir and several nibs of different widths. Home-made pens can be made by cutting a piece of soft wood to a chisel-shaped end.

Ruler : boxwood or plastic, 12″ or 18″ (30 or 45cm), marked in centimetres and inches and the various fractions.

Scales : a set of scales on cardboard showing the following are very useful but not essential.

Inches to a foot		*Scale*
12	=	Full size
6	=	1/2
4	=	1/3
2	=	1/6
1	=	1/12
1/2	=	1/24
1/4	=	1/48
1/8	=	1/96

Compass, suitable for drawing circles up to 6″ radius, drawing board, drawing pins, T-square, set-squares 45° and 60°, and a protractor.

Water-colour paints, supply of brushes of various sizes, a box of crayons and some indian ink and coloured inks.

A great deal of execellent work can be done with nothing more elaborate than the equipment named above. For those who are in a position to add to this the following note on methods may be found useful.

Line Drawing

Visual aid materials can be observed under four major conditions : (i) as subjects of individual examination ; (ii) as wall diagrams for group viewing ; (iii) for communal viewing by opaque projection with the episcope ; (iv) for communal viewing as projected transparencies.

Whatever the method of viewing, the lines of the diagram must be easily visible to the viewer ; that they are often seen only with difficulty and sometimes not at all suggests that the two factors which condition visibility have been overlooked. To be easily visible a line must first be of such a width that it can be seen easily by normal sight from the furthest distance at which it will be viewed—in other words, to be visible a line must subtend an angle of about ½° to the viewer. At 10″ (25cm) distance a line of 1/64 of an inch can be seen, but on a wall chart we may need one ¼″ (6mm) wide. It is convenient to make some experiments and keep records to show what width of line and what size pen is required for visibility at different distances. Secondly, it must be in a medium which is sufficiently 'saturated' or 'intense' to distinguish it from its background at maximum viewing distance–a thin grey line may be visible at a distance of 3 feet or 1 metre but very difficult to see at 30 feet or 10 metres, not because it is too narrow, but because the medium does not show up.

Using Paints

For most purposes ordinary water-colour paints are sufficient. For large diagrams and wall charts it is preferable to use poster paints or powder paints. These are bought in fluid or powder form–the latter merely have to be mixed with water. A drop or two of glue size and a drop or two of water often help the paint to adhere and run evenly.

To cover a large area evenly is not easy. Here are three points to watch: use a large brush and work quickly; dampen the paper all over with clean water first; have enough paint mixed up as required before starting and keep it well stirred while using it–not merely just before using it.

Brushes of several sizes are needed. They should be well washed after use, air dried and kept in a box. Do not leave brushes standing up in a pot of water or the bristles will be damaged.

Spraying Paint

There are many purposes for which a spray is preferable to a brush. Professionals use a commercial air brush operated by compressed air. A similar device can be made with a scent spray which can be worked by hand or fitted up with a supply of compressed air which can be obtained from an inflated car tyre which is allowed to 'leak' into the scent bottle. Simplest of all is the mouth spray. One end is dipped into the paint, air is blown from the mouth into the mouthpiece and a fine spray of paint is blown on to the paper. With the spray large areas can be covered quickly and evenly, or an area can be covered thinly in one place and gradually more thickly as the spray moves across to other parts of it. Templates and patterns can be cut from stiff paper and so held as to keep the spray from certain areas or to direct it on to certain areas.

Lettering

Lettering must always be legible and, if neat and attractive, adds to the appeal of visual materials. As already suggested, a lettering 'pen' can be made from a slip of wood, but metal nibs are preferable. Get several sizes and a holder with a reservoir clip which aids the even flowing of the ink. Good lettering is exacting and time-consuming in execution. For lettering in English various guide books are available. For those whose skill is not well developed it is possible to trace lettering from newspaper headlines with the aid of the tracing table (see below); many varieties of stencil are available for roman lettering.

Tracing Desk

This simply consists of a box with a strong glass sheet forming the top. The original to be copied is placed on the glass and a sheet of paper laid over it. If the light is strong enough it is easy to make a tracing. The tracing desk (Fig. 29) can be built up specially or made by cutting the top off an existing box to give a slope on which a sheet of glass is laid. The bottom will be an open rectangle. A simple method of illumination is to cut a rectangular aperture of suitable size in the top of a table, and to place the tracing desk over this. It can be lit from below by electric lamps, or by reflected daylight. For the latter method the table must be put in front of a window and a white-painted plywood sheet fixed at an angle between the table legs to reflect the light (Fig. 30).

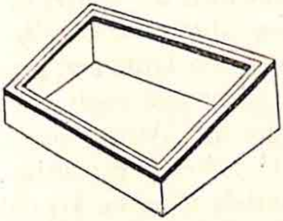

Fig. 29. A tracing desk with sloping glass top.

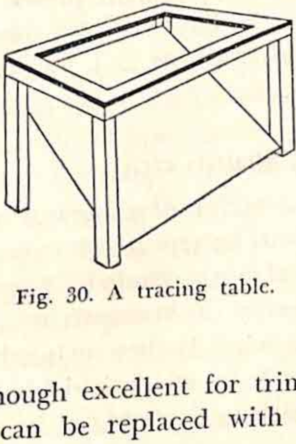

Fig. 30. A tracing table.

Cutting Board

A guillotine, though excellent for trimming cardboard, is expensive. It can be replaced with a sheet of fibre board, a steel rule and a safety razor blade or a very sharp knife.

Modelling Materials of Plastic Type

It is useful to have available plastic solids which can be moulded to form with the fingers or with a few simple instruments—varying from the handle of a spoon to a piece of wood cut with a knife and sandpapered to shape. Potter's clay is excellent and easily obtained. It should be well kneaded before use. Artist's modelling clay is more refined than raw clay, but is expensive.

Both these materials must be kept damp. A good way to do this is to form the clay into balls, each 4″ or 6″ (10 or 15cm) in diameter with a deep hole in the top. Arrange the balls, holes uppermost, in the bottom of a box and pour water into each hole. Successive layers of clay balls can be put one above the other. Fit a tight-fitting lid to the box.

Proprietary materials, usually consisting of clay bound with an oil base are available in several colours. If kept in an air-tight box they remain plastic for years. Others are available which have a wax base. In temperate climates they need warming but in the tropics they are likely to remain soft.

Repetitive Work, Stencils etc.

In preparing a series of diagrams in which various symbols are likely to be repeated it saves time to cut a set of stencils, one of each symbol. These are best made from celluloid because its transparency allows of accurate alignment. The symbol is then painted in with a brush carrying short stiff hairs which is dabbed or stippled over the stencil gap. Simple symbols can be repeated by block printing. The block can be made of a piece of carrot or potato where these are available, or from soft linoleum. It is made by cutting a piece of the base material and then cutting away at one surface until the symbol design stands up on the surface in relief against the lowered background. The printing is done with poster paint or thick water-colour paint to which a few drops of size have been added. It will be found that a quick method of repeating a symbol by block printing is extremely useful in preparing pictorial statistics and graphs.

Identification

Symbols and lettering are used for identification and they should add to the ease of reading the map, graph or diagram. An extremely important point often overlooked concerns the disposition and choice of letters and other symbols on the diagram and the use of guide lines. In some cases, maps for example, names are printed on the area concerned. In other cases, biological diagrams for example, many of the structures are too small to allow this. The keying has thus to be arranged differently. Various methods can be used, of which the following are examples : guide lines with suggestive abbreviations for names ; guide lines with arbitrary codification (e.g. *a, b, c,* etc.) ; guide lines with numeral identification.

The arrangement of the guide lines or rays and the disposition of the lettering and symbols must be considered with care ; they should clarify the diagram by adding meaning and not merely add confusion. These various points are illustrated in text figures which show various methods of dealing with the problems involved. What we might call the 'classical' method is to label the parts of the diagram with a series of abbreviations and give a key in running form below (Fig. 31). It appears doubtful if this does anything more than save space. It could be improved by arranging the legend in tabulated alphabetical form. The writer believes however that identification can be made easier and quicker by arranging the keying itself in a manner which is independent of abbreviations. This can be done in two ways. In one of these (Fig. 32) the spots to be identified are numbered in sequence round the figure and the key is given below. In the other the spots are connected by guide lines direct to a tabulated key which gives names in full and so cuts out the use of abbreviations of any kind (Fig. 33). Either of the methods shown in Figures 32 and 33 allow the pupil to test his own knowledge by covering the key and looking at the diagram which, being free of abbreviations, provides no adventitious aid in identifying structures.

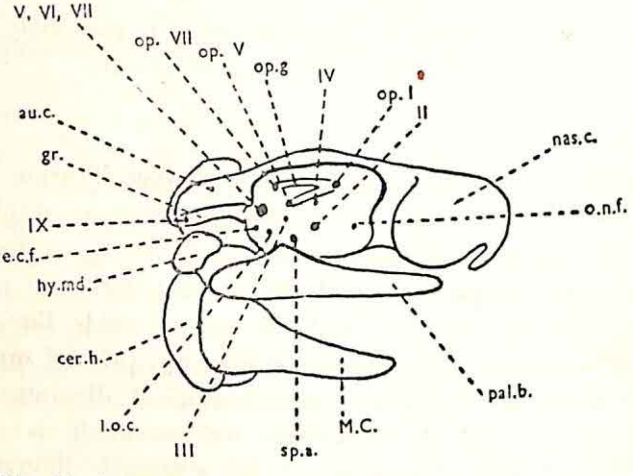

Fig. 31. A biological diagram labelled with abbreviations.

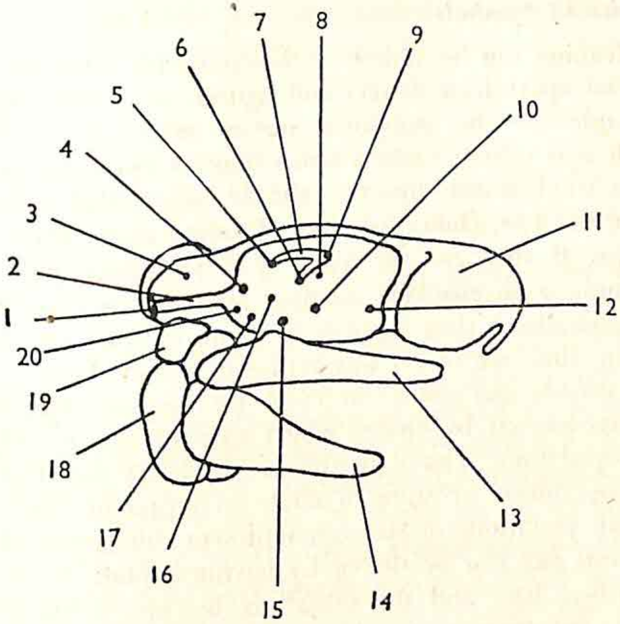

Fig. 32. A diagram with a numeral labelling system.

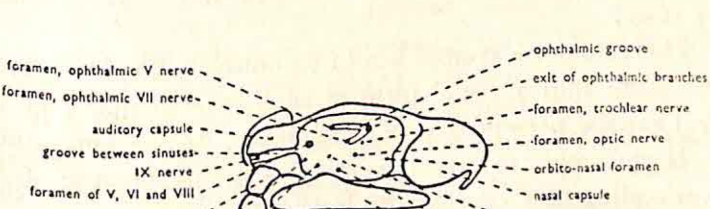

Fig. 33. A diagram 'keyed' with tabulated labelling.

Choice of Symbols

Meaning can be added to diagrams with other kinds of symbol apart from letters and figures, as is well seen for example in the ordnance survey maps. The use of symbols is valuable where much information has to be put on a single sheet, but this should be avoided whenever possible. The choice of symbol raises many interesting points. If they can be made semi-representational their meaning is at once clear without reference to a key list or memorization ; thus there is a saving of time and effort. Where they are in no way representational they can still be valuable and contribute much information. Towns can be represented by circles which vary in size in relation to population. The structure of children's social groups can be shown by using a circle to represent each individual, variations in size can represent differences of age, and one sex can be shown by having a plain black ring on white base and the other sex by, say, a black disc. Flags, cut from coloured gummed paper stuck on pins, map tacks and similar devices are useful because they can be easily redistributed on the base map or diagram so that changes of state can be shown and followed stage by stage.

The value of a symbol lies in its power to condense data and ideas into a visual form of small size so that a great deal can be presented in a small space. At the same time it is not wise to use too many symbols because such overloading may confuse the learner.

The choice of appropriate symbolization is important. Symbols can conveniently be thought of as belonging to several types (see Fig. 34) :

1. *Representational,* in which a small but reasonably accurate drawing of the object is used as the symbol ;

thus a village could be represented by several cottages, a pit location by a drawing of pit-head winding gear and so on.

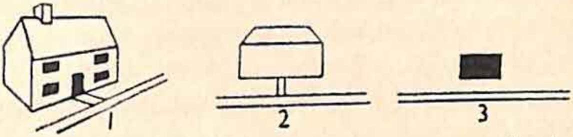

Fig. 34. Three types of symbol: (1) representational; (2) semi-representational; (3) diagrammatic.

2. *Semi-representational,* in which the object is represented by a stylized block drawing; thus a village is shown by a cluster of shapes composed of a rectangular base with a truncated pyramid as the roof, a factory by a rectangular block with a vertical stroke (the smoke-stack), and so on.

3. *Diagrammatic,* in which representationalism is no longer present, so that houses are represented by dots, towns by circles and so on.

These three divisions can be further divided so that symbols soon become extremely subtle devices. It is also extremely important to note that symbolization can be used to deal not only with different units and structures, but with the relationships between them and also with abstract ideas of considerable complexity.

4. *Relationships* (an aspect of differentiation) can be shown by using colour conventions (e.g. county towns in red, others in black), by connecting lines (flow lines, arrows, dotted linking lines etc.) and by drawing in fence-like enclosing lines which include common elements together (e.g. the spheres of influence of various shopping centres or stores in a city). *Abstract ideas* present greater difficulties and must be carefully thought out to reduce them to their essential features; fortunately most of the

abstract ideas we deal with in school life are not far removed from their material bases, which provide useful indications for symbolic technique.

Visual methods can be used not only to illustrate objects, structures and the sequence of processes, but also abstract ideas. Colour, for example, results from differential reflection of light. Thus Fig. 35 shows all the elements in

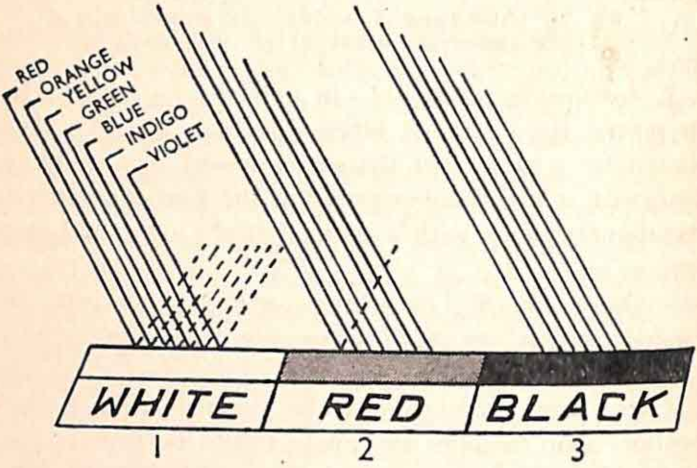

Fig. 35. A diagram to explain colour differences.

light reflected from a surface which we call white. A second surface is called red because it reflects only certain wave-lengths, those which we call red. A third surface absorbs all light falling on it, and we call it black. A more complex symbolism, capable of a great degree of refinement, is the system devised by the Isotype Institute. The essence of this is its ability to deal with relationship and abstraction. Many of those who make their own visual materials use methods which they think to be of the Isotype kind ; in fact this is seldom so. The Isotype technique is richly charged with ideas developed and depicted by a rigorous logic; it is a visual language of considerable complexity of structure which is able to set out complex ideas in easily comprehended non-verbal fashion. Despite its great potential value it suffers from a defect in that it is a language which, though all can read it, only the Isotype Institute can write. Intercommunication of ideas must inevitably be slowed if only a small specialist group can write them down.

Mental factors, as known from test results, provide complex problems of relationship. In particular it must be noted that any one test is not likely to measure a single factor. Instead there may be overlapping, because neither tests nor factors are 'pure'. Here the psychologist is concerned with what he calls variance and co-variance. This is a complex involving the understanding of relationships between abstract entities. Professor Godfrey Thomson used an extremely simple but ingenious method to illustrate this and Fig. 36 is based on his method.

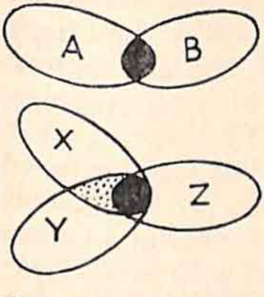

Fig. 36. A diagram to show the relationships of mental factors.

Each oval represents a single ability. The overlapping in (i) shows that abilities A and B have something in common; this overlap is shown in black. In (ii) three abilities are involved, X, Y, and Z. All have something in common, and this overlap is shown in black. Apart from this, however, X and Y have something in common (which is not shared with Z); this overlap is shown by the stippled area.

Differentiation

Differentiation is a special aspect of identification in which one is concerned with areas rather than with spots—

with land between 600 and 900 feet (200 and 300 metres) high rather than with the location of a town, for example.

Differentiation of areas and of relationships is often shown by the use of washes; they may be in monochrome or in varying colour. This is a valuable method, but it has a number of pitfalls, amongst which is the difficulty of standardization. An easy way to deal with this, in monochrome or polychrome, is to prepare a comparative chart of standard tones and colours keeping with it a note of the makers of the media used and the method of mixing, such as *indian ink, Winsor Newton, diluted with own volume of water,* × 2 *own volume,* etc. It will then be easy to make up a new supply approximating to the original wash used and one which can easily be standardized against the comparative chart. The application of a wash to a large area is less easy than it looks. It is also less easy on some kinds of base than on others. When wash methods are to be used it is wise to test out the intended base first and also to try various methods of application. In some cases an even coat is more easily obtained by application to a surface which has already been damped with clean water. In all cases it is wise to be sure that a plentiful supply of the proposed colour wash or other medium is available, to use the largest possible brush and to work as quickly as possible.

Differentiation is often obtained by the use of cross-hatching with lines drawn parallel (but at different angles for different factors) or intersecting. Instead of lines other devices may be used, such as dots, circles, crosses and so on. These are useful methods when applied to small sizes and small areas but they take up a lot of time when they are to be applied to a large wall chart. Where such devices are to be used superimposed on a wash base it is wise to consider which shall be applied first. In general

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it should be the wash base, which should be perfectly dry before the symbols are added.

The methods of differentiation are bound up with differences of significance and meaning which must be made perfectly clear. An important point here is to try to work out some kind of standardization of method from the beginning. Within the confines of a single subject this is usually possible, as for example in using red for arteries, blue for veins, black for nerves etc. in zoology. When such a standard system can be achieved there is need to make only one master card or key which will apply to a whole series of visual materials. Where it cannot be used it is essential to include a key in every chart and picture made.

While colour can be used for materials to be viewed by eye or with the episcope, its use in the making of diagrams which are to be photographed may result in several difficulties. Photographic materials are differentially sensitive to colour, thus while red and blue lines are visually distinct in a diagram they may be far less readily distinguished when recorded photographically. These, and other related points, must be taken into account in making a series of diagrams as the basis of a set of slides or for a filmstrip. Though expensive, it is possible to make photographic transparencies in colour on several varieties of colour film. Information concerning the photographic aspects of making visual aids materials is given elsewhere (Chap. XIII). Much more complete treatment of this topic is to be found in books on photography.

It is sometimes necessary to differentiate between the relative importance of certain processes, connexions and relationships. This can be done by various means. One method, which could be used to show the relative density of traffic or the freight tonnage along different routes, is to draw lines of different widths which are proportional to the variations in the process being considered. An example is shown in Fig. 37. It is important to ensure that the narrowest line is easily visible under the intended conditions of viewing. A second method, to show the relative production of various materials in several countries, is to draw maps in which the scale of the countries varies as shown in Fig. 38. This diagram shows the normal map of the world on Mercator projection in (1). The other two maps show the relative numbers of population and the heavy industry of three areas by drawing them on different scales.

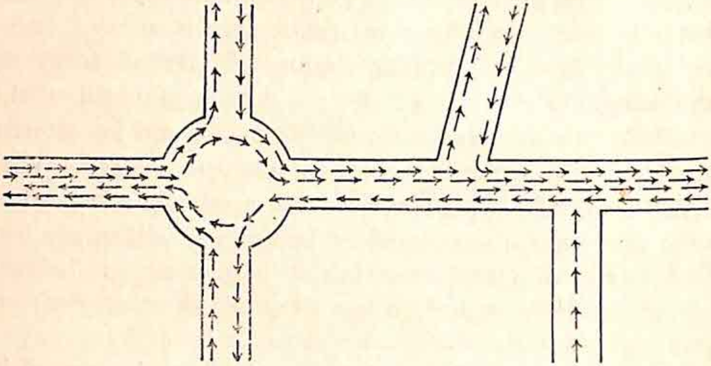

Fig. 37. Differentiation of traffic flow by use of arrows.

Devices for Arresting Attention

One of the simplest methods of arresting attention is to use a single brilliant colour against a monochrome background, or to use a heavy black line or area on a diagram which is otherwise mostly white. Attention can also be arrested and guided by guide lines, arrows and the like which are additive materials and not part of the

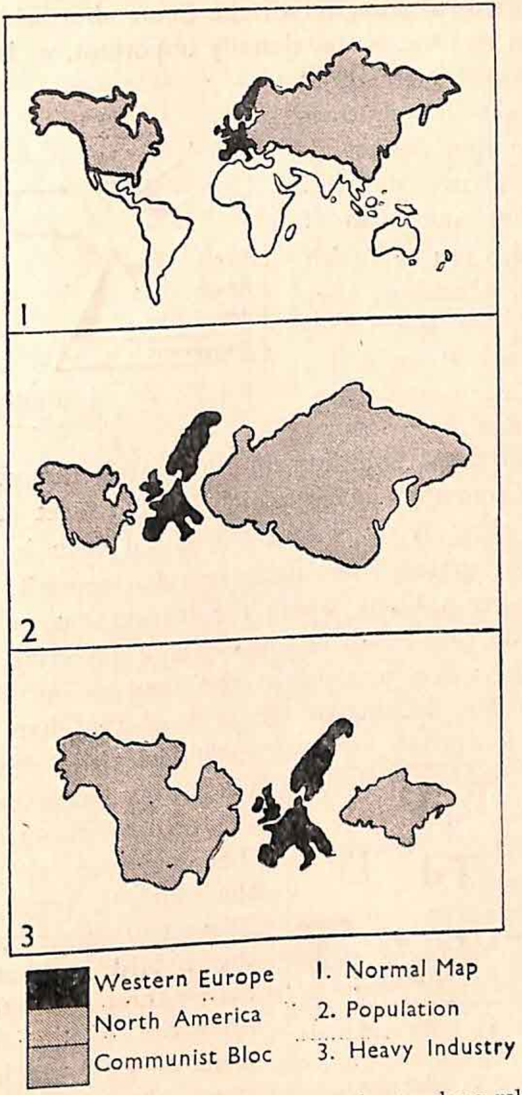

Fig. 38. Differentiation by varying scales to show relative importance.

representational material of the figure, but which direct attention to what is functionally important, as in Fig. 39. While direct methods of this kind often attract attention they do not always challenge thought. This they must do if visual aids are to enrich learning, because they can only do this where the learner is an active participant in the teaching situation. Our visual aids must arrest attention, but not arrest thought. There are two common devices which seek to meet this point. One of these is to present the visual item in question form by giving the necessary background material and leaving a blank where the learner has to think to supply the answer—which may be a pictorial figure, a numerical value, a word, symbol and so on. By lifting a paper flap, looking at the back of the chart or some such device the observer can check his accuracy against the actual answer (Fig. 40). The example given shows the simple relations of Mendelian inheritance, first the hybrid generation and then three of the four categories of the first filial generation in which segregation occurs. The fourth category, the pure recessive, is covered by a flap which must be lifted to disclose the

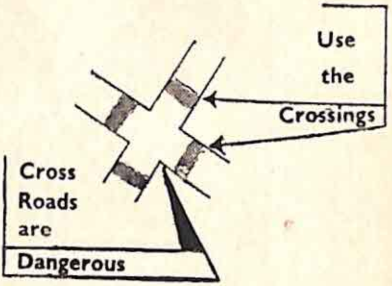

Fig. 39. Use of attention-arresting devices.

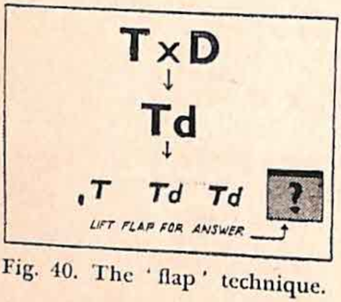

Fig. 40. The 'flap' technique.

proper answer. By using a strip of 'scotch tape' it may be possible to move the flap into different positions. A variation which is sometimes used is the presentation of a problem by visual means together with a solution which is obviously wrong or absurd. The danger in this is that while most learners would see the error not all would seek the right answer; and there are usually a few who do not even realize that there is an error!

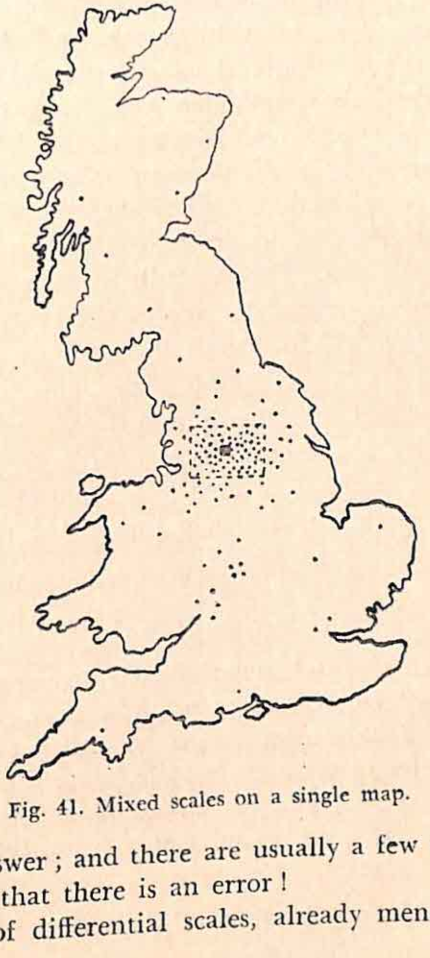

Fig. 41. Mixed scales on a single map.

The use of differential scales, already mentioned, also provides a method of emphasis for certain features and items, and is effective for dealing with situations where the data to be presented are differentially distributed. The former case is obvious and requires no comment. As an example of the latter we can take the making of social studies maps to show the home origin of students attending a central institution, or the distribution of purchasers over the sales area of a big store. In both cases the majority of the locations will cluster round the subject of the study while the remainder spread out in decreasing density over a larger area. To present the data on a map drawn to one scale might demand a large map, while if the scale were altered to reduce the size of the map it might not be possible to distinguish the single locations of the central area. The difficulty can be overcome by superimposing a large-scale map of the central area on a small-scale map which extends to the limit of the distribution (Fig. 41). The example shows how, in connexion with a problem of distribution, the area around a particular city has been drawn upon a larger scale and inserted on a map of smaller scale. Indeed it is possible to make effective use of a map comprising regions drawn to three scales.

Enlargement and Reduction of Scale

In preparing visual materials one frequently needs to reproduce a diagram or map on a scale which differs from that of the original, or to bring two maps on different scales to a common scale. Here the job is to be able to enlarge or reduce the scale of a drawing or map, and to do it as quickly and easily as possible. There are several methods:

1. *Proportional Compass or Divider.* This consists

of two flat metal strips with long slots through which a nut and bolt passes (Fig. 42). The metal strips are calibrated and have pointed needle ends. Suppose we wish to enlarge or reduce a map by five times. We loosen the screw and set the strips in relation to each other so that one pair of points is five times as far apart as the other pair. To enlarge our map we use the divider points which are closer together to measure distances on it, and we then use the points which are five times as wide apart to transfer these points to our drawing paper. By taking a series of key positions, say a series of towns, we soon build up the skeleton of a new map in the enlarged scale. The dividers can be set with the aid of the scale calibrations—in our case we choose '5'. Thereafter, providing they are still pivoted round this point, the relationship between the gaps at the end will remain 5 to 1 however we alter the angle between the two arms.

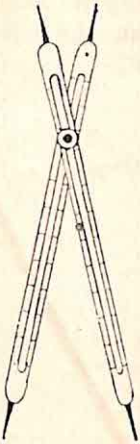

Fig. 42. Proportional dividers.

2. *The Pantograph*. This (Fig. 43) consists of an extending trellis arrangement which works on a principle similar to the proportional compass. By using the calibrations we can set it for known alterations of scale. In use we put the map which is to be redrawn on a table top with a sheet of paper beside it. The pantograph is fixed at one point and with the tracer we follow out the original map. Movement is transferred through the trellis to the pencil-holder which is moved across the paper sheet and draws a new diagram upon the selected scale.

3. *By the 'Method of Squares'*. A map can be readily enlarged by drawing lightly on it in pencil a grid composed

of squares with sides of 1/10″ (3mm). On a large paper sheet we now draw a grid with larger squares, say with sides of 1″ (25mm) to give us a 10 × enlargement. Detail is now transferred by freehand drawing from the small

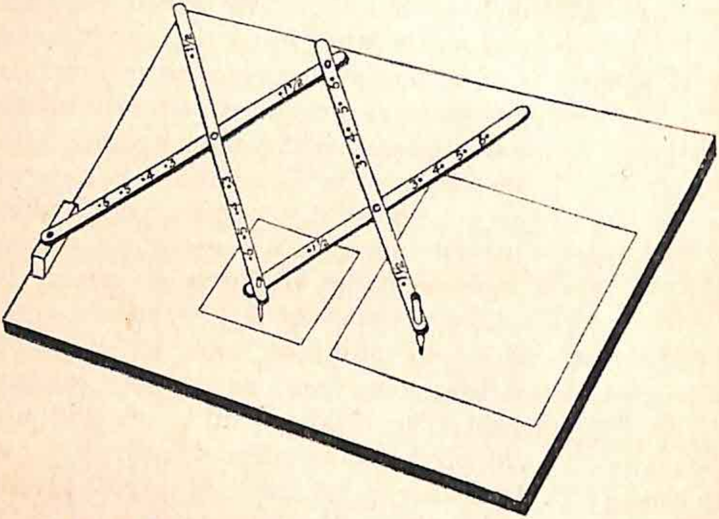

Fig. 43. The pantograph in use at a scale of two linear magnifications.

map to the large new one by drawing it in square by square and preserving the same relations in the large map as exist in the small one (see Fig. 44).

4. *With the Episcope.* Place the diagram or map in the episcope together with a ruler, and focus the image on a wall. If a 10 × enlargement is required adjust the position of the episcope until one inch on the ruler in the machine is enlarged to 10″ (25cm) on the wall. Pin a large sheet of paper on the wall and trace in the necessary details.

As the episcope is now being used to project over a smaller distance than is usual it may be difficult to focus.

The optical conditions are such that, as the lens approaches the screen, the object (in this case a map) must be taken *further* from the lens. This can usually be achieved by keeping the holder on which the map is placed further away from its usual position by now allowing it to spring

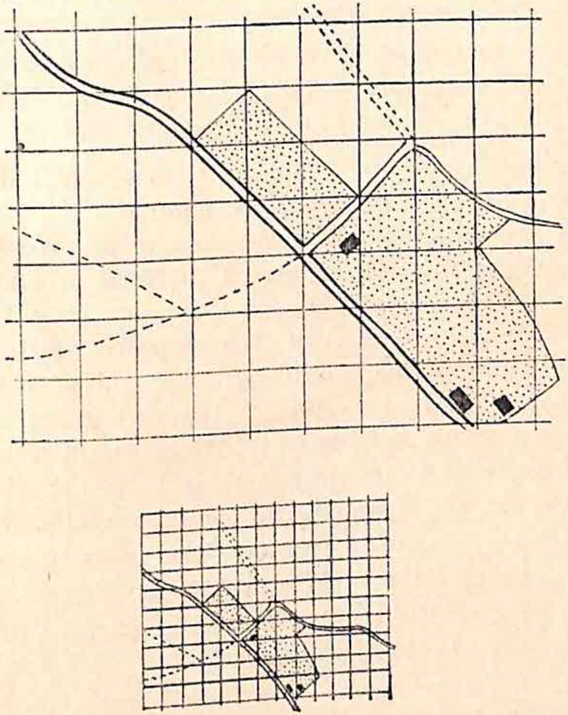

Fig. 44. Enlargement of a map by the squares method.

upwards. The map can be kept flat with a loose sheet of glass. In the design for a simple episcope this point was dealt with by an easily made accessory device.

In all these methods care must be taken to set up the paper, the map and the necessary apparatus so that no movement will take place which will alter the scale accidentally while the job is being done. Note also that the methods can be combined : thus a skeleton enlargement can be made by the square grid method and finished off with proportional compasses.

Enlarged Microscopic Drawings

Teachers of biology often need to make accurate drawings at greatly enlarged scales of the details of microscopic sections. Various methods are available :

1. *By micro-projector.* Project the image on a sheet of paper and draw in the details as required.

2. *By projection through the microscope.* Work in a dark room. Set the microscope on the floor or under the shelf of the glass-topped tracing table (see page 145), or on the floor below a sheet of glass supported between two stools. Illuminate the object, with the aid of a mirror, with as much light as possible. The real image will be projected upwards and can be traced on to a sheet of thin paper (better still, tracing-paper) laid on the glass. In order to get the required degree of magnification, or even to achieve any degree of clear focus, it may be necessary to adjust the distance between the microscope and the glass with the aid of flat pieces of wood or books under the foot of the instrument.

3. *With camera lucida or prism.* These commercially produced devices fit over the eyepiece of the microscope. By working in a subdued light with a sheet of white paper beside the microscope the images of the object and of a pencil point on the paper can be brought into coincidence. The observer traces the virtual image apparently seen in the instrument on to the paper and so makes an enlarged drawing.

4. *With filmstrip projector or photographic enlarger.*

For some purposes—particularly with slides showing boldly stained gross detail—satisfactory enlargements can be made with either of these instruments.

A Perspective Drawing Device

It is often necessary to make perspective drawings of specimens, models or apparatus. Even for those with considerable skill in draughtsmanship this is a time-consuming task. It can be done quickly and easily with the simple device shown in Fig. 45, originally described by Staniland. It consists essentially of a frame which carries an eyepiece aperture and a glass sheet. The object to be drawn is placed in a suitable position on the far side of the glass sheet and looked at with the eye close to the aperture at E. The outline of the object is then drawn on the glass sheet with a glass pencil to give an outline in true perspective. The glass is removed and the figure traced on paper. For most purposes the dimensions should be about 15″ (37cm) for B and about 10″ × 7″ (25 × 17·5cm) for G. E should be about 1/16″ (1·5mm).

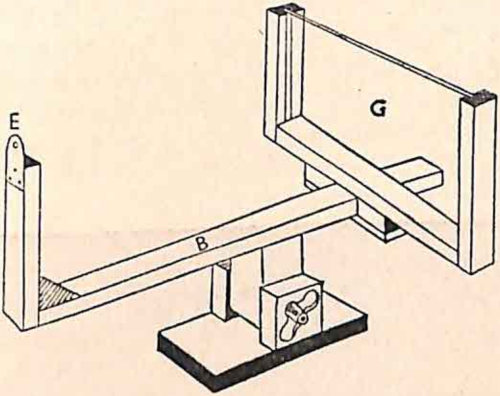

Fig. 45. A perspective drawing device.

Scraper-board

This consists of a cardboard base coated with an even layer of black pigment. When scratched with a stylus, or a needle mounted in a wooden handle, the white shows through. Thus a drawing in white lines on a black background is made which has much of the appearance of an etching. This technique is much used in making book illustrations. Its interest to the teacher lies in its use in making photographic materials (e.g. filmstrip) by a single process, because when photographed the negative produced consists of black lines on a white background. The same effect is also obtained—but with much less 'finish'—by photographing diagrams drawn in white chalk on a blackboard. An example of a scraper-board diagram is shown in Fig. 46. Scraper-board is also available in other colours.

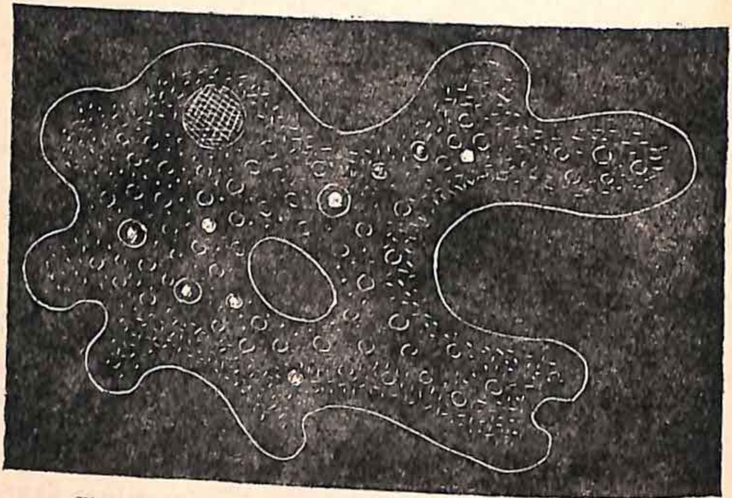

Fig. 46. An amoeba drawn on scraper-board, giving white lines on a black background.

X

VISUAL MATERIALS IN TWO DIMENSIONS

MOST OF THE VISUAL MATERIALS which are prepared for educational purposes are two-dimensional, i.e. they are flat pictures in one plane. By our experience of reality and our understanding of perspective we are able to translate these into three-dimensional reality. The artist and draughtsman make use of various devices which enable us more easily to effect this translation: by 'drawing in perspective', by using lines of varying thickness or colours of different degrees of intensity. The teacher who wants to make the best of visual aids must learn something of the various devices which can be used to extend understanding. It is very largely in the field of two-dimensional materials that we can most easily prepare our own visual aids.

Pictorial materials are readily available in these days of illustrated magazines, newspapers, advertising brochures and pamphlets. The teacher should collect, and encourage his pupils to collect, material of this kind on as lavish a scale as possible and so build up a pool of material which can be turned to good use in teaching. The immediate and important problem of storage and preservation has been dealt with in a previous chapter. Here we are concerned with the more educational aspects of using such material and exploring its potential uses.

The most obvious use is as background or orientation material used for the purpose of giving some first degree of understanding. The pupil, the young pupil in particular, has a restricted experience and has not fully developed his skill in using what he has. In listening to talk and radio and in reading he is continually coming into contact with words and ideas which are bare symbols for an experience he has not yet had. Any school-book is full of such symbols and the pupil is thus presented with numerous situations which he learns to remember—and he can do this without gaining any understanding. How does a child in Ceylon gain any conception of the snowy wastes of the Arctic? What does a description of town life convey to the child in a remote rural village? To what extent does a child in one country gain a sympathetic understanding of life in other countries? It is here that we need pictorial presentation. Our school-books lack it because of the cost of illustration, but such material is at hand, as already noted, on every side; wherever there is a school there is usually at least one person who reads papers and magazines, and most of these contain pictures. But these will only have teaching value if they are first collected and then properly prepared and used.

Having collected together a suitable pool of material, the teacher must next decide how it is to be organized. Does he want a series of single pictures or does he want to arrange them in some special grouping according to content and purpose? These points we have discussed in a previous chapter. Our purpose here is to carry the problem still further. 'A single picture is worth a thousand words'—most of us have come across that statement. Nevertheless a *series* of pictures will allow us to do greater justice to the extending of meaning, the following of logical sequence and relations and the analysis of detail. A single picture of a snow-capped mountain helps the child of the tropical lowlands to a new understanding. How much better, though, to have a series of pictures, starting from his own environment and tracing the transition to Alpine conditions step by step. Then he can see the changes of vegetation, the effects of climate, and the continuous adaptation of ways of living. But even with complete series of such purely representational pictures understanding may still not be complete.

Representational methods can be applied to the preparation of what we might well call diagrams rather than pictures. The artist moves away from purely representational pictures towards such techniques as impressionism. The draughtsman, with different motives, also moves away from the exact copy of reality and makes use of a number of devices of formalized type which finally become the diagram pure and simple. In other words he has moved from representational to diagnostic, from actuality to the symbolic. In order to make such visual aids and to make better use of such aids when made by others it is worth giving some attention to the various possibilities.

The technical drawing made by a draughtsman is a rigidly formal presentation of reality as seen under fixed conditions and as represented by a series of accepted conventions. Let us take a simple structure made in wood such as is shown in Fig. 47. This is actuality as seen from one position. The draughtsman's task is to prepare a drawing from which a craftsman can reproduce this object. He does this by using four drawings of the object as seen from different positions :

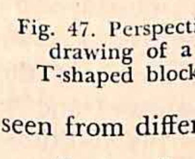
Fig. 47. Perspective drawing of a T-shaped block.

(i) view from the front–front elevation ;
(ii) view from above–plan from above ;
(iii) view from below–plan from below ;

(iv) view from the side–side or end elevation.

A drawing prepared in this way is shown in Fig. 48. Such a drawing, when it is of a simple object, is easy to understand without special training. If it were at all complicated this would not be so. It is, however, often necessary to provide the layman with an understanding of a complicated structure and at this point the draughtsman would turn to other devices which aim at increasing understanding without necessitating special training. The most effective way is usually to turn to the use of perspective drawings, but even these require some knowledge and experience for their interpretation. The writer has found it useful to introduce pupils to perspective drawings with the aid of specially prepared diagrams and to link these up with a device for increasing the understanding of the draughtsman's formalized technical drawing. It is a matter of opinion and experience as to how one should deal with the situation. Some would start with the representational and go through perspective drawings to the draughtsman's drawing; others would arrange matters differently. The important thing for the teacher is to be aware of the possibilities, to understand the principles involved and to realize that such techniques are not beyond his abilities—though he may not achieve the finished perfection of the professional. Here again he must take comfort in the important point that the drawings are, for him, not ends

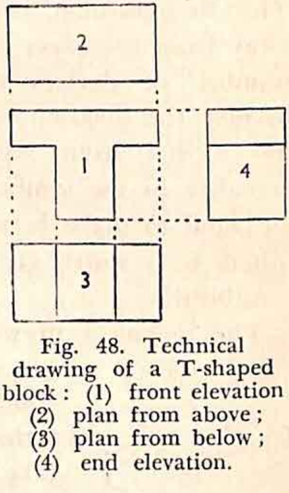

Fig. 48. Technical drawing of a T-shaped block: (1) front elevation; (2) plan from above; (3) plan from below; (4) end elevation.

in themselves, but means to an end—improved understanding on the part of his pupils.

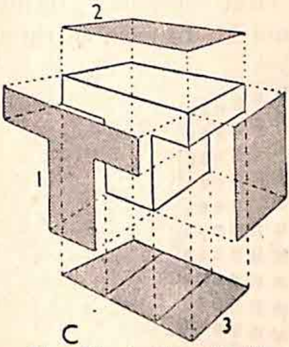

Fig. 49. A diagram to illustrate the relations of a perspective and a technical drawing.

Taking again the structure already used in Fig. 47, we have seen it in perspective and in a draughtsman's drawing. To give greater meaning to the latter, to help the beginner to look at that but think of the object as it appears in the photograph, and to link up the various views drawn by the draughtsman with the object, we can make use of the device shown in Fig. 49. Here we have, as it were, put the object into a special frame of reference, a transparent cube, and projected on to the walls of this the views which the draughtsman drew. This has been found useful in helping pupils to understand the conventions of elevations and plan—and more helpful than merely saying: 'Well, look at the thing from in front, the side and above.'

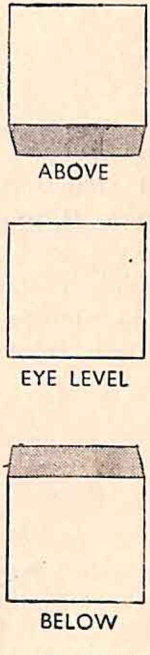

Fig. 50. Position of object seen in relation to eye-level of observer.

A next step should be to introduce the idea of perspective. Experience suggests that while this idea develops naturally in the process of growing up, many older pupils (and even teachers) do not achieve complete familiarity with it. Again a simple start can be made. First the appeal to experience: 'Have you ever stood on a railway bridge and looked along a straight railway?' Next one might prepare two series of diagrams or photographs of a cubical box and large 'angular' building—such as are shown in Figs. 50 and 51. In each of these figures show how the appearance is related to the point of view and discuss the apparent behaviour of parallel lines. If you have an episcope these figures can be projected on a wall and the lines drawn in to a vanishing point. To familiarize pupils with the effects of perspective and viewpoint it is useful to have a simplified house drawn from different positions, as in Fig. 52. Another

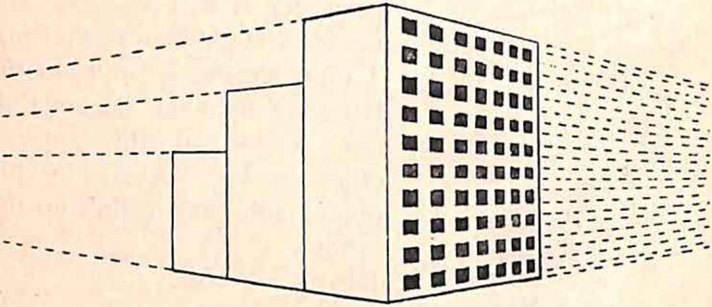

Fig. 51. Perspective drawing of a large angular building.

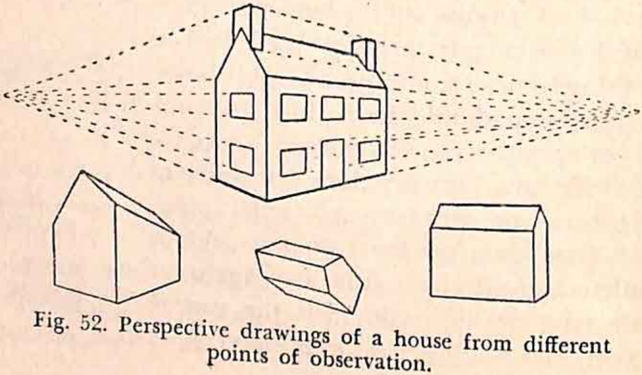

Fig. 52. Perspective drawings of a house from different points of observation.

useful step would be to set up a simple problem situation, such as is shown in Fig. 53, where the pupil has to decide

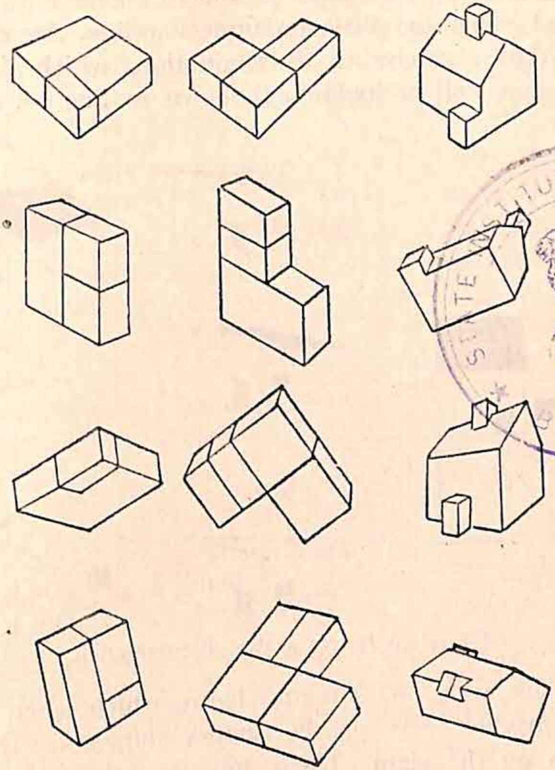

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Fig. 53. Perspective drawings from varying positions setting a problem in recognition.

which of the three lower figures represents the top ones in each column drawn from a different viewpoint. The idea behind such a series is simply to stress the point that diagrams are not merely to be *looked at* but *thought about*: that by thinking one can get more out of the situation than shows at first sight. It is important to encourage this attitude everywhere, but particularly in the East, where education has long been so highly verbal and where so much emphasis is placed on mere memorization and much too little on understanding. An example of a simple exercise in discrimination, which demands thinking as well as looking, is shown in Fig. 54. On the left of this is a flat 'cut-out' figure which when folded would produce any of the shapes shown in the two columns on the right. These, however, differ from each other in regard to the door, window and half-black roof of the little 'shanty'. The pupil has to decide which of the six would be made by folding up the cut-out figure. After a few such elementary exercises as have now been suggested, most pupils should be in a position to understand that the use of perspective in drawing aims at giving an appearance of solidity to a figure drawn in a single plane. As we are not concerned with the teaching

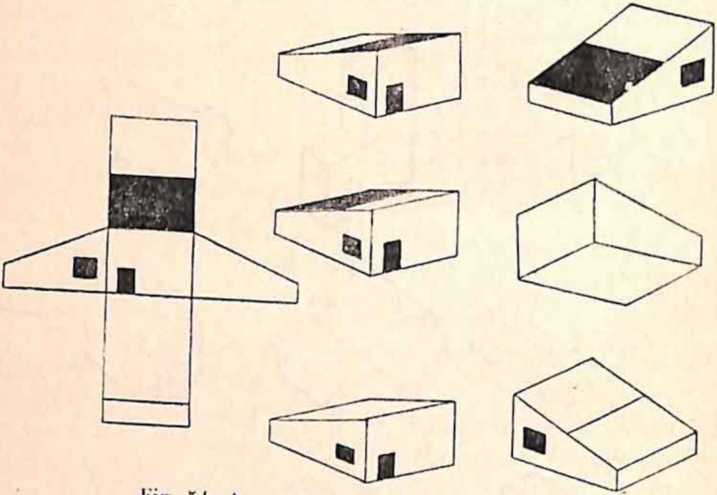


Fig. 54. A test in spatial discrimination.

of technical drawing the matter can be left at this point so far as the pupil is concerned. The teacher however should make himself more familiar with the methods the draughtsman uses in preparing technical and perspective drawings, in order that these methods can be adopted (though perhaps in a simplified way) for producing visual aids.

Two important points must be settled here. First, the size of the drawings: shall they be small or large? Large drawings can be made on backing paper, kitchen paper or even newspaper, as mentioned in the previous chapter. They can then be used as wall sheets. The major disadvantage is that the costs are increased because more raw material is used. The chief advantage is that anyone can make and use them for communal viewing. Small drawings should not be made merely for individual viewing but, where an episcope is available, they should be of a size which allows of projection with the episcope. Thus they can be used for communal viewing, and enlarged copies can be made by projection on a big sheet of paper. The chief disadvantage of the small drawing lies in the purely mechanical problem of getting detail into restricted space.

The second important point is concerned with what we may call legibility and is bound up with the thickness of lines and the size of lettering. A very thin line can be viewed by the individual, but this could not be seen by a group because the viewing distance would be greater. Roughly speaking we might say that for comfortable observation anything, object, line or print, must subtend an angle of $\frac{1}{2}°$ to the observer. At a viewing distance of 10″ (25cm) a thin line fulfils this condition. In making wall diagrams teachers often forget that the line must be very much thicker, because it will be looked at from a greater distance.

To turn now to the draughtsman's methods, we should note that he makes less use of the impressionistic approach than, say, the commercial artist, and instead aims at work which can be classified as follows:

1. *Representational:*
   - (i) Impressionistic, on a reduced scale.
   - (ii) Realistic, of the following kinds: the 'technical drawing'; true perspective; formalized perspectives.
2. *Diagnostic:*
   - (i) Semi-representational.
   - (ii) The 'plan'.
   - (iii) Schematic-relational.
   - (iv) The analytical drawing.
3. *Symbolic:*
   - (i) Semi-representational symbolism.
   - (ii) Analytic symbolism.

The most convenient way of dealing with these is to go through the series, offering comments which may help the teacher to understand and use them.

Representational drawing is the method most used for conveying ideas to the general public which has no training in the interpretation of more specialized techniques. For the same reason it is probably the most suitable for school use, especially with younger children or with those whose work does not include some study of the more formal methods. Representational drawings, however, range over a wide scale: at one end they may be called 'natural', at the other end they are formal.

Diagnostic drawings are made in order to select the essential features of a structure and emphasize these rather than the multitudinous details which may be present. These too can be arranged in a series, though it is less easy to put this in a linear order of ascending complexity. It might indeed be noted that the complexity lies in the mental abstracts required to construct and interpret the drawings rather than in the figures themselves. This may be seen by reference to Fig. 55, which shows two examples of diagnostic drawings. In A the

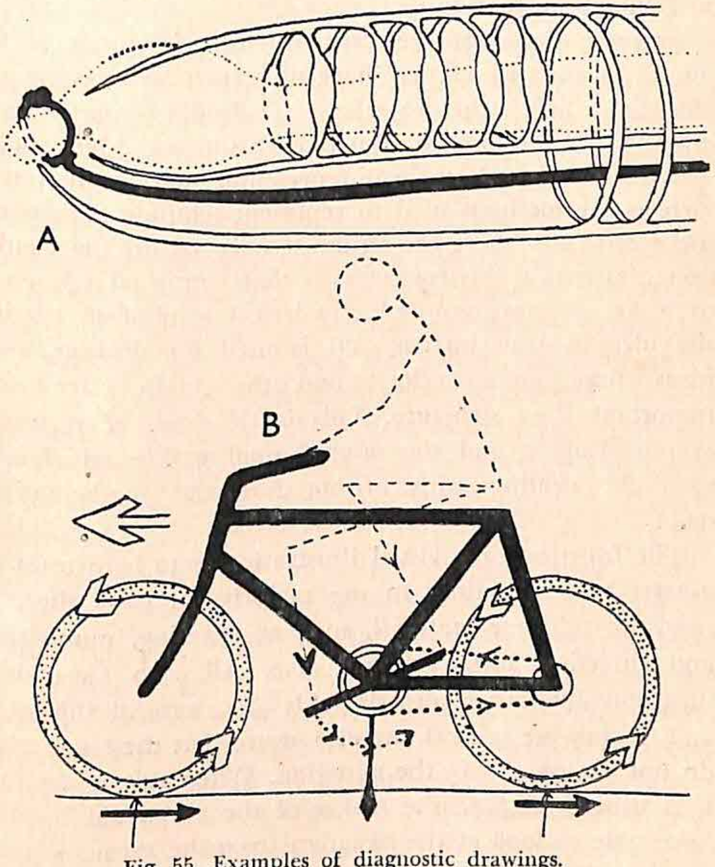


Fig. 55. Examples of diagnostic drawings.

relations of gut, nervous system and vascular system in an earthworm are shown in a way which helps the student to fuse together the information he has acquired from dissecting, examining micro-sections, and reading. In B is shown a simplified attempt to illustrate the forces acting on a bicycle in motion.

Symbolic drawings are used when it is necessary to convey an idea which may have no structural basis, or an idea in which structure plays a subsidiary part. Two examples will suffice to illustrate this point. Many map symbols are based on semi-representational symbolism—such as the methods used to represent temples, swamp or rocky outcrops ; here the figure at once recalls the condition of the real environment so that continual reference to a key is not required. Analytical symbolism carries the idea a stage further and is used for dealing with ideas where number, velocity and other qualities are more important than structure. This is the basis of pictorial graphs, Isotype and the more formal graphs which are used for dealing with arithmetical and mathematical data.

The function of a visual illustration is to help towards greater understanding. In the majority of cases there is need for *additive material,* such as lettering, numbering and direction lines and the like. All who have used diagrams and other pictorial aids are aware of this need and, if they are critical, are also aware that these materials do not always clarify the situation. When this is the case it is usually because the maker of the visual aid has not been able to look at the situation from the learner's point of view. To this point we shall therefore give some attention, though it must be noted that the treatment must be brief and from a personal point of view. Others will hold different views and it must be realized that we have little in the way of objective knowledge to guide us.

Legends

Every figure and picture should bear a legend which defines the object shown, locates its origin if this is important to understanding, and makes it clear from what viewpoint the visual aid has been made. If necessary such data as magnification, time of the year and so on should also be given.

Lettering and Numbering

Diagrams and pictures which are at all complicated need more explanation than can be printed on them in full. It is thus usual to use some kind of identification key. Some examples of how this can be done are given in Figs. 31 and 32 which show the use of letters, figures and layout. Which of these is most convenient will depend partly on the type of diagram, the load of key material to be inserted and so on. These figures show a common method based on abbreviations which have either a recognition or a mnemonic value. In a complicated figure with a heavy keying load much time is wasted in locating the key letters even when they are tabulated in alphabetical order. For this reason it may be found more simple, and much quicker, to use single alphabetical lettering or serial numbering as will be seen in some of the figures. A related problem concerns the use of guide lines and here too, as these figures show, considerable variation is possible. Most commonly a guide line is drawn from an object to the abbreviation or other coding used to identify it—the pupil then has to use the legend key to find what the coding means. Here use is made of two processes when, by adopting the kind of layout shown in Fig. 33, only one is necessary because the guide line joins the object to its identification.

Certain mechanical problems arise in connexion with lettering and numbering. The thickness of line must be appropriate to the size and this must be related to the viewing distance. The style adopted must be related to ease and speed of execution and above all to legibility. Lettering like many other arts, has become the subject of unnecessary complication. Gothic characters, for example, may be full of appeal, but are usually out of place when one is concerned with clarification. Many simple and legible styles are available but, whichever is chosen, it must be remembered that lettering is an exacting and time-consuming task and should, whenever possible, be made easier by one of the devices already mentioned in Chapter IX.

Differentiation

It is frequently necessary to use some kind of differentiation in order to show degrees of relative importance or the order of events in time, or to distinguish between different parts or areas. Lettering and a descriptive legend will do much to help, but there are other devices which must not be overlooked.

In diagrams showing a series of sequences or of events in a particular order one can indicate the order by lines of different thickness or of different kinds. Variations of density or velocity or loading can be shown in the same way as is done on traffic-flow maps or shipping routes showing annual tonnage carried. In making such visual aids the first line drawn should always be that which represents the lowest value concerned. If this is made of a suitable thickness to allow viewing, all others will certainly be easily seen because they will be thicker. Where the differentiation is to be shown by coloured lines strong saturated colours should be used.

Differentiation between areas or between the various elements of a structure can be shown by washes in monochrome or in different colours. The main difficulty is to achieve standardization but this can be overcome by sticking to one brand of pigment and making a colour chart or comparator. It might also be useful to make a record of the degrees of dilution with water so that previous effects can be copied more quickly and more certainly. The application of a colour wash to give a uniform effect and leave the paper flat is not easy. A trial should always be made on a piece of the intended base because not all will take a wash and different materials react differently. A plentiful supply of the colour wash must be made up and trials made to determine whether it is best applied to the dry paper or to one already damped with clean water. The brush used should be as large as possible. In using wash colours it is also important to decide whether guide lines, lettering and the like should be put in first or after the application of the paint–in either case be sure the first is dry before the second is added.

In connexion with the use of colour a further point is to be noted, if one is making a diagram which may later be photographed to make a transparency in black and white for projection. Photographic emulsions are differentially sensitive to colour of different kinds ; blue tends to record very lightly while red or yellow appears a dark grey. Photographs can be made in colour but the processes are fairly expensive. This expenditure can be avoided by using the episcope and by drawing and painting the diagrams to a suitable size–which should include a key so that it appears on the screen. As far as possible there should be uniformity in the use of colour. Always use the same colours for the same altitude bands, stick to red and blue for veins and arteries and so on.

Differentiation can be achieved in black and white by the use of cross-hatching with lines of different types or by covering areas with stipple (dots), small crosses, circles and so on. This takes a great deal of time and may easily lead to confusion unless care is taken to ensure that the various conventions are easily distinguishable.

The ordnance and survey maps make excellent use of symbols and these can also be used in making visual aids. In many ways they are an improvement on purely conventional lines and patterns because the symbol can be selected to suggest meaning directly without the need to use a key continuously. Map symbols, especially on topographical maps for general use, are representational wherever possible. The use of symbols in pictorial presentation has however gone far beyond this, an advance which is probably best seen in Isotype. This may be looked upon as an attempt to develop a universal language of signs which can be used to describe not only material things, events and their relationships, but also ideas and the relationships between them. The teacher who decides to make use of symbols must keep clearly in mind an important point, that they aim at increasing understanding and must not be too complex, or they may add to the difficulties instead of reducing them. The development of symbolic presentation is so absorbing a problem that there is a danger that it may become an end in itself or become so abstract as to be beyond the pupil's understanding. Before we too readily accept some of the attempts to present educational matter to young children, or even to older ones, there is need for a good deal of research work.

The use of Charts

In dealing with events which are complex or which spread over a period of time, it is usual to make use of what have become known as 'charts'. Under this name are found a variety of diagrams which, in general, all share one common feature: they are 'process' or 'flow' diagrams. Provided that the sequence to be followed in their interpretation is clear and that they are not overloaded with details, they can be extremely useful. But, as research has shown, even to follow the simplest process diagram needs experience, and possibly training, because the mental functions involved in relating abstractions to realities and putting these in their frame of reference (time, space, sequence etc.) are far from simple. In order to help the pupil in every possible way it is essential to make good use of very obvious conventions for showing scale and for marking key points in a sequence or process. To illustrate some of the major problems in making and using charts of this kind we shall now examine some typical examples that deal with events of which the sequence is linear in one case and cyclic in the other.

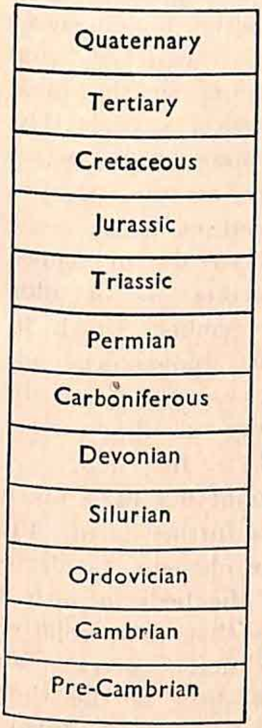


Fig. 56. A simple type of linear chart.

Linear sequence is concerned with events or processes which follow an order in time which has no pattern of repetition. Cyclic sequence involves the operation of a pattern of repetition. We shall examine one or two examples of each of these two groups.

A chart of the type dealing with linear sequence is frequently used by geographers, geologists and biologists who want to give a broad indication of the 'sequence of the rocks'. Typical examples of such charts are shown in Figs. 56, 57 and 58. In this series, Fig. 56 shows linear sequence and grouping in the great geological periods. Fig. 57, however, is an advance on this because, instead of being essentially a list of names, it makes use of additive symbols which by their appearance suggest something of the nature of the various rocks. In Fig. 58 account has been taken of a further factor, the time element, by drawing the beds in such a way that their relative thickness gives an indication of the time which elapsed during their formation. It seems clear that more

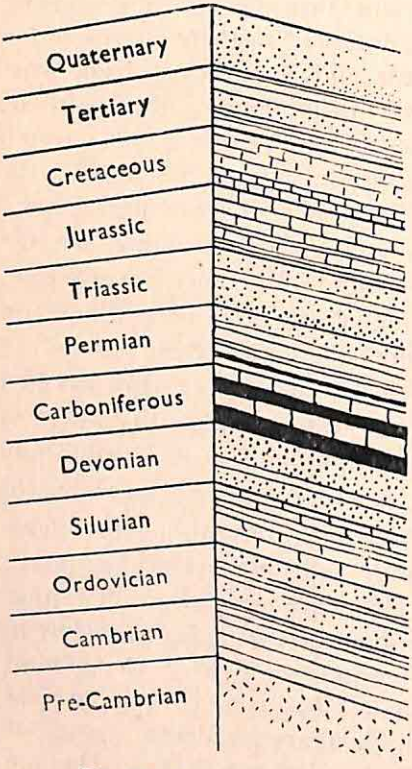


Fig. 57. A more elaborate linear chart.

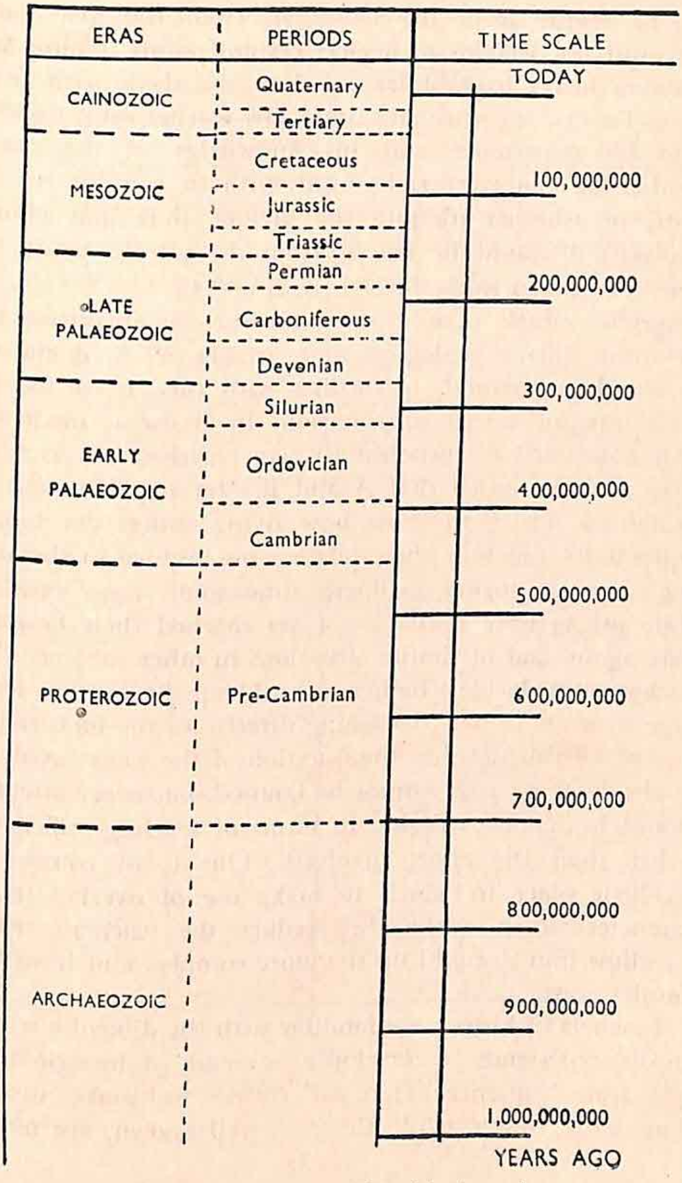


Fig. 58. A geological table with time chart.

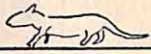
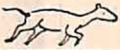
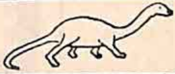
can be learnt from the last than from the first, but this must not lead us to neglect certain points. Figure 58 carries a heavy load of factual data and deals with two sets of factors, sequence and time. The teacher must decide from his experience and his knowledge of the class whether he can start right away with so complicated a chart, or whether (despite the greater time and effort involved) it would be better, from the pupils' point of view, for him to work through A, B and C.

Another closely related topic concerns the succession of life forms during geological time. In Fig. 59 A, B and C we see three methods of dealing with this. In A use is made only of verbal presentation. In B use is made of representational pictorialism to give enriched experience. In C we have much that A and B offer together with a formalized device to show how living things developed sequentially and how their relative importance in the life scene varied during geologic time—some now extinct, while others have perhaps not yet reached their heyday. Here again, and in similar situations in other subjects, the teacher must decide whether to build up the content load stage by stage rather than going directly to the final stage. In making this decision the question of the work involved on the teacher's part cannot be ignored, but every attempt should be made to decide in terms of teaching efficiency rather than the effort involved. This is of course an excellent place in which to make use of overlay transparencies which, while they reduce the teacher's work, yet allow him to build up the more complex end from the simpler start.

Teachers of history are familiar with the difficulty which pupils experience in developing a sense of historic time and time sequence. Here of course we make use of time-charts which, while they are well known, are not as

QUATERNARY	Modern Man
TERTIARY	Rise of Man Higher Mammals
CRETACEOUS	Early Mammals Extinction of great reptiles
JURASSIC	Birds
TRIASSIC	Dinosaûrs
PERMIAN	Land animals
CARBONIFEROUS	Early reptiles Sharks
DEVONIAN	Fishes
SILURIAN	Lung-fishes
ORDOVICIAN	Corals
CAMBRIAN	Trilobites
PRE-CAMBRIAN	

A

QUATERNARY	
TERTIARY	
CRETACEOUS	
JURASSIC	
TRIASSIC	
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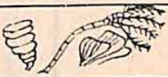
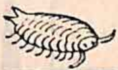
SILURIAN	
ORDOVICIAN	
CAMBRIAN	
PRE-CAMBRIAN	

B

Fig. 59. A and B. Two methods of showing evolutionary data in relation to geological sequence.

widely used as they should be. This is because some teachers are just unaware of them or of their potentialities.

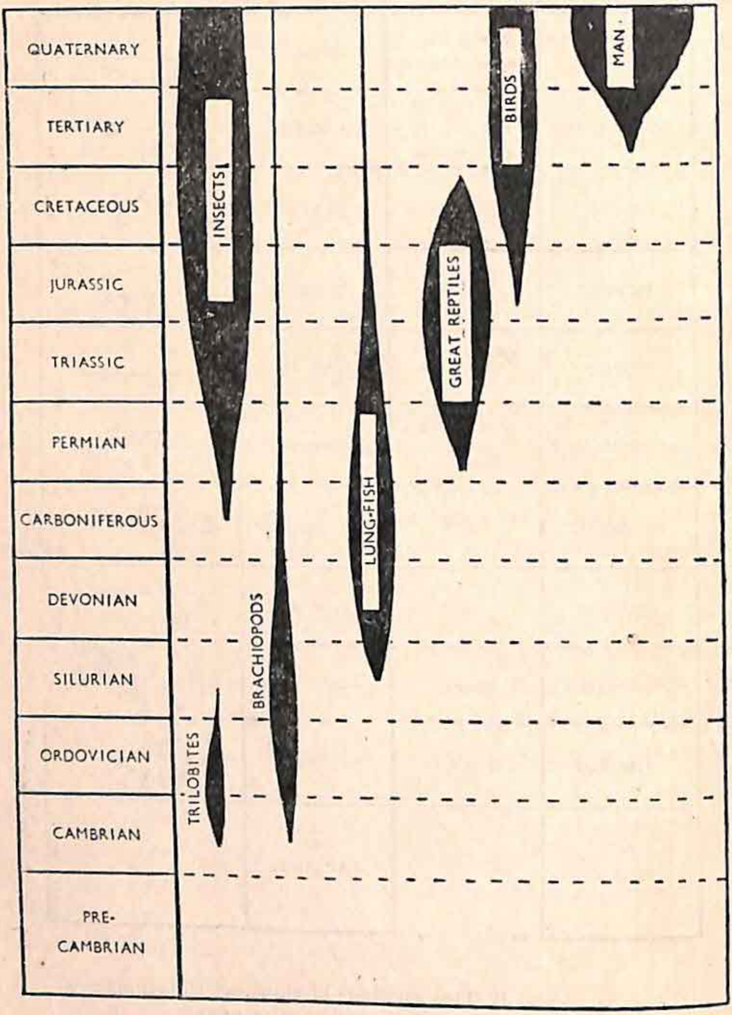


Fig. 59 C. A third method of showing evolutionary data in relation to geological sequence.

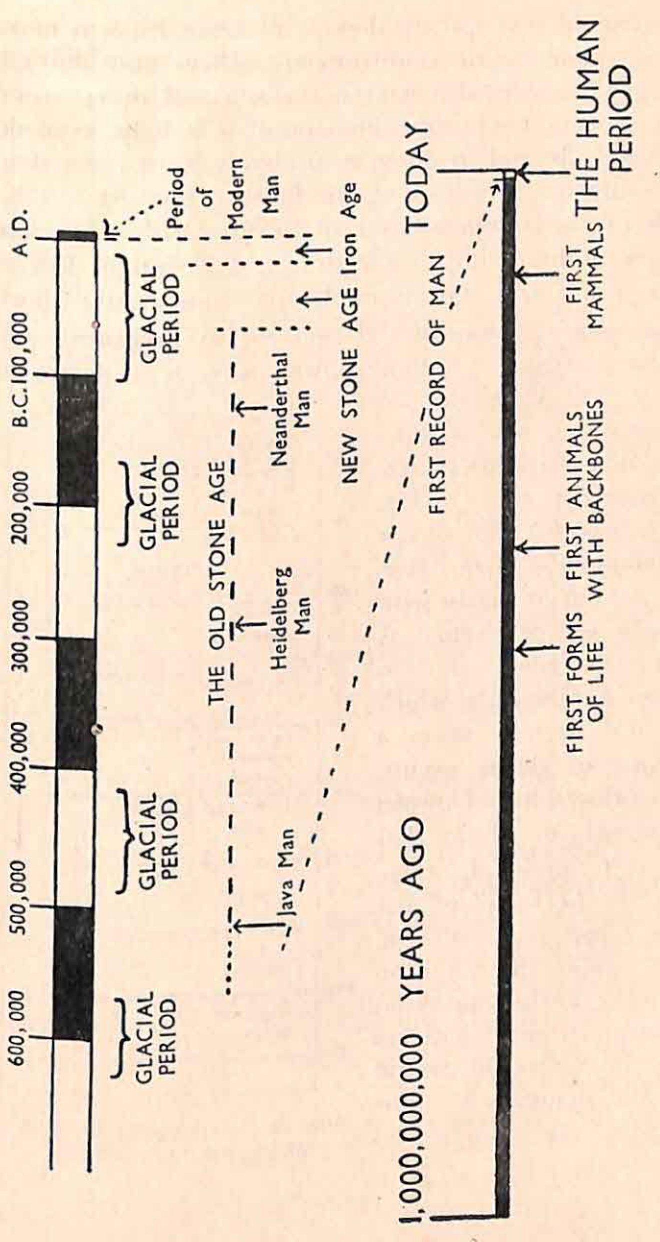


Fig. 60. A linear scale to illustrate the briefness of the human period in relation to geological time.

Others would perhaps say they don't know how to make and use them, while unfortunately others find the job too much trouble! In making these, as all other visual aids, one should remember that pupils can help, even do the whole job, and in doing so probably learn more than they would by merely seeing the finished product.

One of the common ways of dealing with time-sense problems is by a linear scale drawn as a straight line, a spiral or a zigzag. For example, the comparative shortness of man's history in relation to his prehistory and evolutionary time is often shown by such a device as Fig. 60. The same kind of scale can be used to show the relative duration of historic time periods as in Fig. 61. The disadvantage of the simpler type of linear time-scale is that it deals with a single set of events. A further problem is to develop a time-scale which does not merely show a sequence of dated events, but distinguishes between the events to show that some are political, some events in the world of arts or science, and so on. Once again the solution appears to lie in some kind of combined scale such as in Fig. 62, where the central band shows domestic affairs and the others refer to

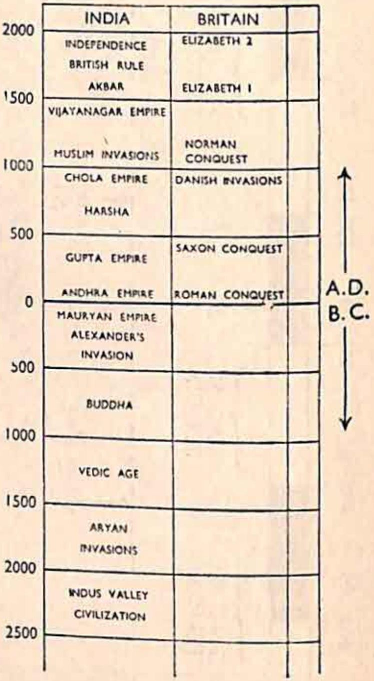


Fig. 61. Relation and duration of historic time periods.

events under different headings. A well-known form of this is often used as a wall frieze running right round a classroom just above the level of the top of the doors and windows. Each wall could be taken to represent a particular period and, as the multiplicity of events tends to increase as we approach our own times, it would be possible to use different time-scales for the different walls.

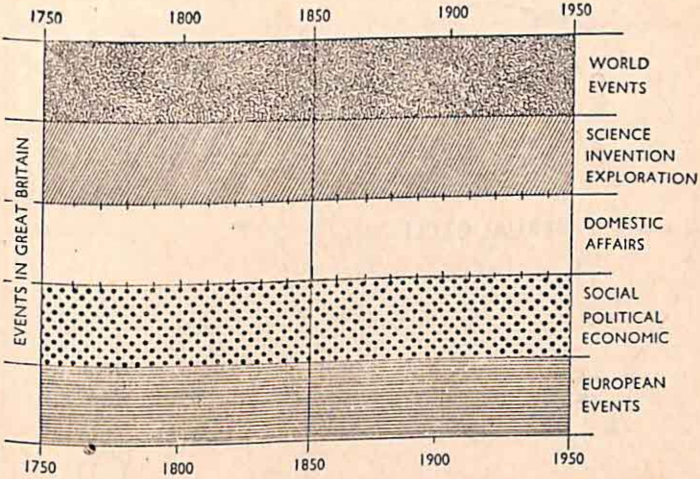


Fig. 62. A device for comparing national events of various kinds against world events on a linear time-scale.

Cyclic scales are used to deal with phenomena which occur in a 'closed circuit' which is continuously repeated. In Fig. 63 we see the application of this method on different levels of complexity to the life history of the malarial parasite. In A we have first the life cycle of the mosquito. In B we have this together with information concerning the blood parasite. In C we have the whole story presented in a cyclic diagram which shows the sequence of events, the relation to the two hosts and the changes and processes in the life of the parasite. There are many processes and events in which this kind of device

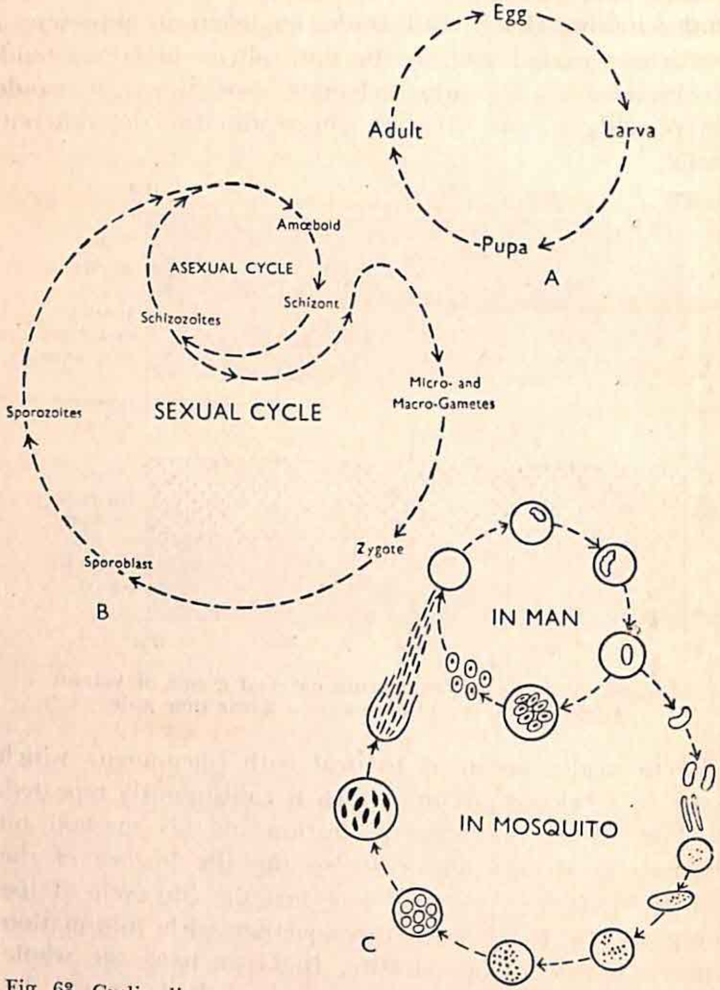


Fig. 63. Cyclic diagrams of the life history of the malarial mosquito and parasite: (*a*) the mosquito; (*b*) the parasite; (*c*) the complete life cycle.

is useful, such as the great 'cycles' in nature (e.g. the nitrogen cycle), in economic events, in the changes of climate and the like.

Another problem which the teacher has to face is that of showing how modern methods have necessitated the reshaping of old concepts. This perhaps is best seen in connexion with modern transport which, by altering the relative accessibility of places, has altered our concepts of space and time. This can be dealt with by time-and-distance scales which can be made in various ways, one of which is shown in Fig. 64. In order fully to appreciate the importance of air travel it is usually considered

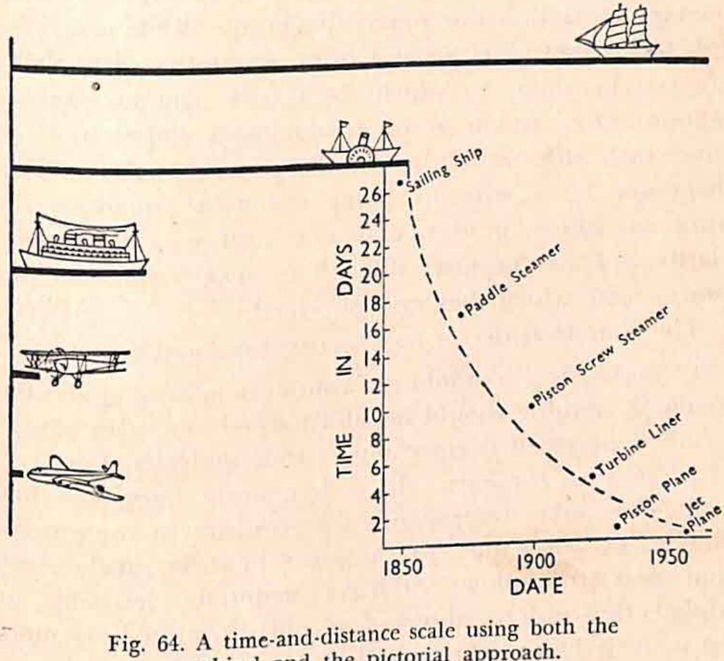


Fig. 64. A time-and-distance scale using both the graphical and the pictorial approach.

necessary to make use also of special maps; these are discussed later.

One of the most common uses of visual aids, particularly in chart form, is to trace the sequence and relationships of a series of events by means of 'process diagrams', or 'flow diagrams' as they are also known. Such diagrams can be simple or complex, concentric or linear, and either semi-representational or purely diagnostic. While it is difficult to lay down any general rules concerning them there are certain points to which the teacher should give attention. One, which is of fundamental importance, is concerned with the ability of the pupil to follow these diagrams. It is wise to point out that situations do arise in which process diagrams confuse rather than clarify and may be more difficult to understand than the process with which they are concerned.

The characteristics of an effective process diagram are:

1. *Simplicity*: it should not contain a mass of irrelevant material, nothing should be added merely to 'gain effect'—unless the result is clear and extends understanding.

2. *Obvious sequence*: it is frequently forgotten that while the maker understands the sequence in the process the learner does not, so that this must be made clear and easy to follow. Additive materials, lettering in alphabetical order, enumeration and direction lines must be used if the pupil is to follow it easily.

3. *Appropriate scaling*: industrial, commercial and scientific processes take time and different parts take different times. In some way this should be indicated on the diagram, not merely as an aid to understanding it but also because the time factor is important in itself.

4. *Use of key diagrams*: it is because many processes and relationships are complex that flow diagrams are called

for, but they may themselves be unavoidably complex. Thus there is need for a two-stage approach in which a much simplified key diagram is used to give a simplified over-all view acting as an introduction and background to the more complex diagram.

5. *Use of multiple diagrams:* one of the most common mistakes in visualization is to attempt to make one diagram do too much. This is avoided, in many cases, by using a key diagram, as suggested above. In others, of greater complexity, it may be wise to extend the number so that, in a three-stage process in which each stage is very complex, one might have:

(i) Key diagram to the whole process.
(ii) Key diagrams *a*, *b* and *c* to each stage A, B and C.
(iii) Process diagrams of A, B and C separately.
(iv) Process diagram of the whole process.

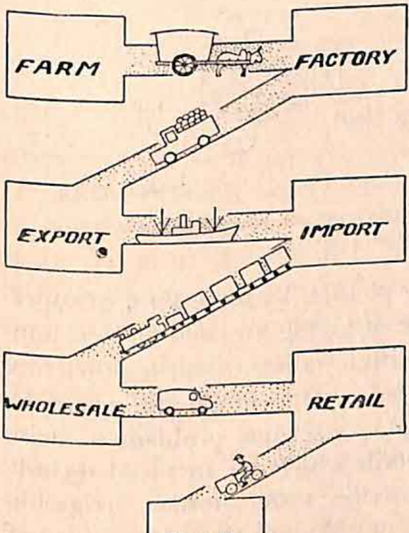


Fig. 65. Process or flow diagram showing food cycle from farm to home.

Some examples of flow or process diagrams which illustrate these points are shown in Figs. 65 and 66. The salient points are mentioned in the legend. The teacher who wishes to use such diagrams should proceed through three stages ;

1. Decide which are the important points in the sequence to be illustrated.
2. Ensure that his treatment adequately illustrates the process while observing the criteria mentioned above.
3. Decide, by consideration of pupil response, whether his diagram has in fact made understanding complete.

We turn now for a moment to another style of visual presentation which cannot easily be classified under a single heading because it exhibits a number of variations. The words 'montage', 'inset' and 'multiple-style presentation' have been used, but none of them is really sufficiently embracing. Montage can be considered as the building up of a composite picture, by some kind of superimposition, for the purpose of giving an over-all view aiming at the orientation of attitude rather than the imparting of specific details of knowledge. One might, for example, take the question of drought, a serious problem to man, animals and crops. The details which are involved include rainfall, topography, land usage, water storage, irrigation and water distribution on one side and the effects of water shortage on the other. Each is a big problem in itself and the series is a complex whole. What matters is not so much that pupils should gain a detailed knowledge of each point but that they should be given an attitude to

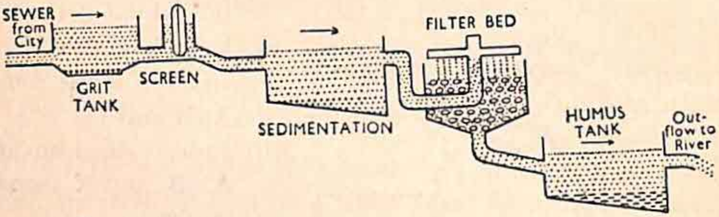


Fig. 66. Process or flow diagram showing the process of sewage disposal.

the problem : an attitude which affects what they do–and which lasts into adult life and leads them to be sympathetic to new ideas, such as new ways of tillage, contour cultivation, hoeing, drainage and water conservation. In this, as in many other cases, the barrier to progress lies in the difficulty of breaking traditional attitudes and of replacing them with new ones which make for the more ready acceptance of new ideas and new methods. Here montage, especially photo-montage, can play an important part because it can bring together several ideas in simple terms–and because it makes an emotional as well as a rational appeal.

Though the idea may appear complex and the method seem to demand a considerable amount of work, it will be found that neither impression is necessarily true. Moreover, this is a place where pupils can be called on to help–with added benefits in terms of learning. Those who decide to try the idea out should start with something simple which calls for nothing beyond what is readily available. In most cases this will be pictorial material cut from newspapers and magazines. The simplest case of all would be the use of a couple of pictures linked by relationship with a common idea and perhaps with some kind of diagram. An example is shown in Plate 1 which makes use of two magazine pictures. A more complicated example, made by scissors and paste from magazines is also possible.

Another field for exploration is the 'pictorial map'. Examples of this are well known in advertising and tourist agency work and it is a method not unknown in junior geographies. It could well be extended in relation to the teaching of history and geography–and again it offers many opportunities for the pupils to take part. An outline map can be prepared by enlargement (see page 163) and on this illustrations can be pasted—these can be cut from magazines. Better still would be the preparation of several maps, each showing pictorially a different aspect, such as scenery, animals, 'how man lives' etc. It will be found that this simple device has excellent value in arousing interest and giving some degree of concrete meaning to words which far too often are but verbal images. It can of course be used for many other purposes besides geography and history, for instance in giving a visual background to literature, in connexion with science teaching, and so on.

A somewhat more formalized approach to the pictorial map is shown diagrammatically in Fig. 67. Here we have

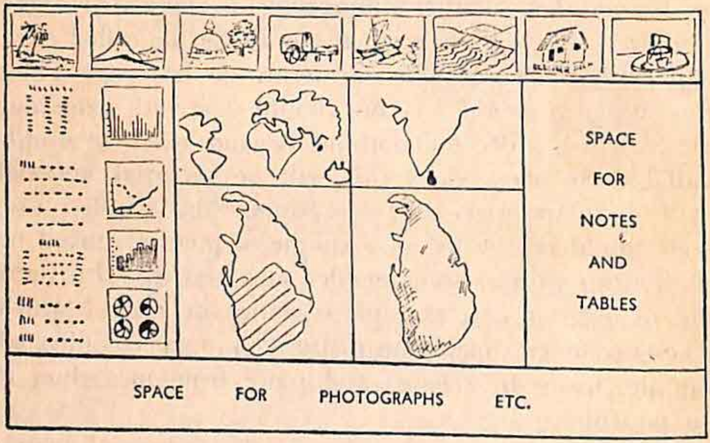


Fig. 67. Scheme for a formalized pictorial map.

four maps as the centre of a panel, while the borders are used for tabulated data and pictures. There are many possible variations to this kind of multiple presentation, which suggests that the panels should be prepared on a stiff cardboard base to give permanency.

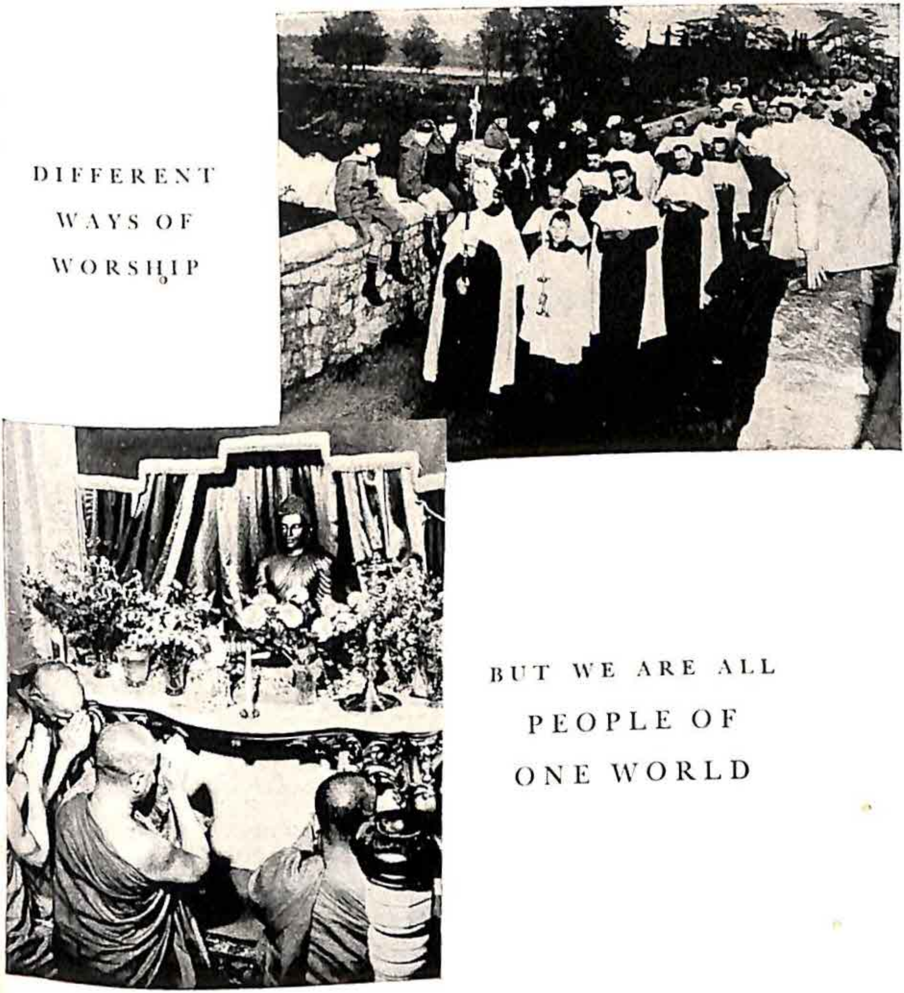

DIFFERENT WAYS OF WORSHIP
BUT WE ARE ALL PEOPLE OF ONE WORLD

PLATE I

People of One World—a poster made up from magazine pictures.

For some purposes, especially where one is concerned with showing relationships, what is called the 'overlay' technique will prove useful. In this one has a basic map or diagram printed with rather heavy lines. Over this a sheet of transparent or translucent paper on which other data is printed can be folded so that the superimposed data can be seen in relation to the basic data. For those who like some degree of elaboration it is possible to have four overlay sheets, one attached to each side of the base map. Such complication, however, should only be used where it achieves a purpose which can only be attained in that way—and there are not many cases (in school work at least) where it is an essential device. Those who try this method will find that extra thin superfine tracing-paper is suitable for the overlay if the base diagram is very bold. Transparent material, such as cellophane, is tempting and indeed ideal, but it is not easy to write on. Indian ink will sometimes run smoothly if the surface is quite free of grease or if a drop of saponin or other wetting agent is added, and the same is true of water-colours. In some cases powder colour can be mixed with amyl acetate to give a wash which can be put on sparingly with a brush. Wax or glass pencils, which can be obtained in colours, will usually take well.

In making one's own maps, and all other visual materials, it should be remembered that wide simple treatment can deal with large and complex ideas. Too often maps are overloaded with detail, whereas, Fig. 73 shows, they can be simple, yet effective.

As education becomes more and more a process of socialization, so that social studies and project method work become increasingly important, greater attention is likely to be paid to practical studies of the social environment. Whether this is the village or the city, the county or the continent, there will be a need for visual presentation. The pictorial and mixed-scale map will play a part here, the overlay map will be of value, but there will also be a place for the social base map. The purpose of this will be to present the important social facts of a region or to show the relations between these facts as they exist in two or more regions. Social base maps of various kinds have been widely used outside the school—they have an obvious place in it. The detailed methods of their preparation will vary, but certain general principles should be followed and in this connexion the following points are worth noting:

1. Plan the project as a whole and decide exactly what maps are to be prepared, what is to be shown on each and by what symbols.
2. If possible have all maps on the same scale and use a constant series of key colours and symbols.
3. Draw (by tracing, enlargement, etc.) the basic outline maps with a bold, hard outline. Make tracings from these and enter all results first on the tracing and, after checking, transfer to the final sheet.
4. Never merely copy a map of the locality—send the class into the field with it and have them check it over on the spot.
5. Remember that the social base map is a visual aid, a means towards a greater degree of social understanding. The moment it becomes an end in itself—something being 'got ready for the Exhibition'—then its value begins to be lost.

An example of a social base map is shown in Fig. 73 which compares and contrasts the differences and characteristics of two types of city area, one in the overcrowded slums, the other in a favoured residential district.

Social base maps are of considerable value in connexion with civics and social study work and are very much used in this way in England and America.

The treatment of maps is more properly dealt with in books on geography, but it is not out of place to refer here to one other kind of map—the 'air-age map'. The aero-

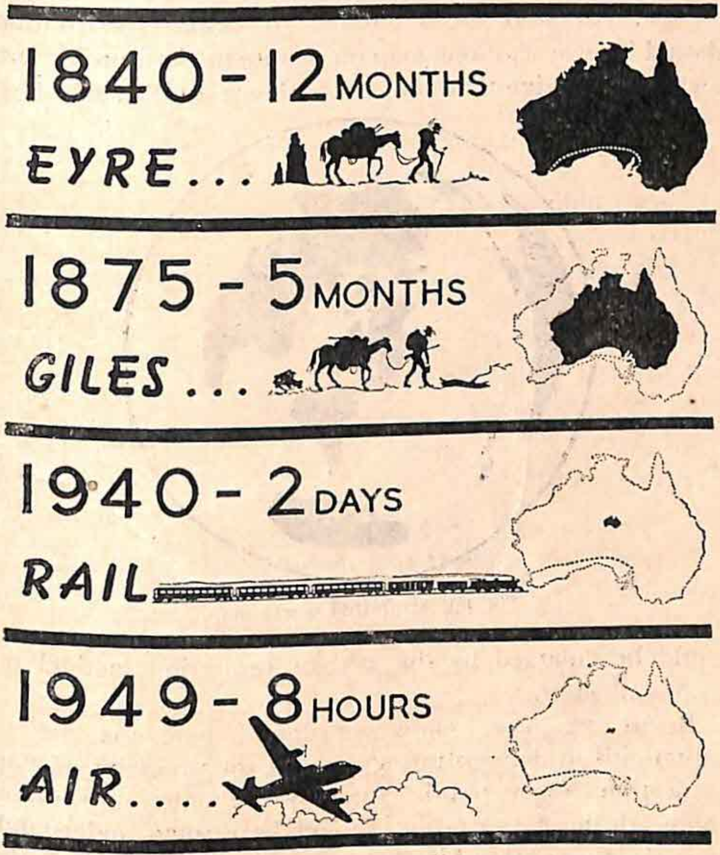


Fig. 68. The 'shrinking world'—a diagram to show the apparent effect on size of increased speed of travel.

plane, by reducing the time required to travel from place to place, has in effect caused the world to shrink—an idea illustrated in relation to Australia in Fig. 68.

Any kind of plane projection of a spherical surface will result in distortion of shape, area, distances or bearings. Most children get their visual picture of the world from Mercator maps, but these have a very considerable distortion. All who are interested in better visualization should have at least one map on a more modern projection, such as the azimuthal projection shown in Fig. 69. This could be enlarged by the grid or projection method on to a wall sheet.

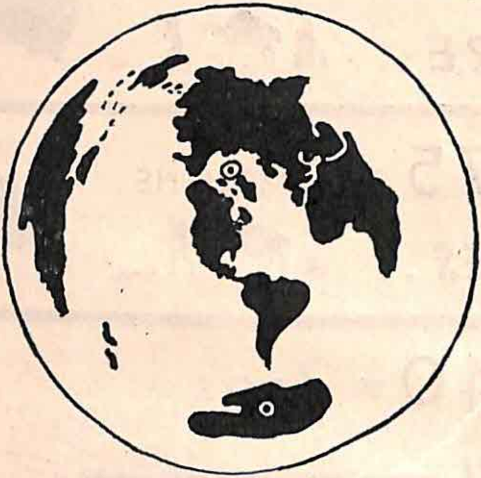


Fig. 69. Azimuthal world map.

Before we leave maps we should note the use of visual aids in demonstrating some of the problems of map projection. Every pupil, especially the older ones doing more advanced geography, should have some understanding of the relationship between the flat map and the spherical globe. Some hints as to how this may be achieved can be gathered from Fig. 70. This shows how projection from the centre of a globe on to a cylindrical sheet results in exaggeration of distances in a north-south line. This is greater in the polar region than in the lower latitudes, as will be seen by comparing the projection of the three angles in the figure. In preparing these, as all other visual aids, there should be co-operative work by pupils and teacher—both can learn in the process.

As our final example of two-dimensional visual aids we can take graphs. Although graphical methods are frequently used in school work, especially in connexion with mathematics, they are capable of many more applications. The limiting factor has been the idea that graphs should only be used for rather exact demonstrations and problem solving. There are however further possibilities, especially where the purpose is to give a general background picture for orientation purposes. Among the various possibilities we may mention the following:

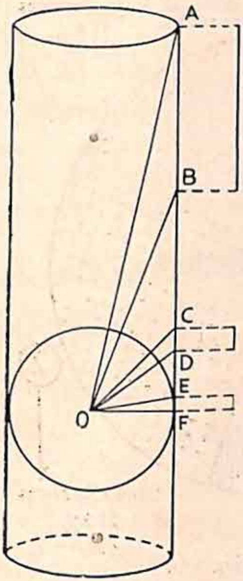


Fig. 70. The relation between globe and map, showing why the Mercator map exaggerates distances in higher latitudes.

1. Quadrant or sector methods which demonstrate relationships as a function of a circle. These are particularly useful where one wishes to show how conditions and relationships vary with time. An example is shown in Fig. 71.

2. Bar graphs are useful when it is desired to show

variations of frequency or intensity with respect to a series of factors as shown in Fig. 72.

3. Histograms, which can be looked on as a special kind of bar graph, are extremely useful (Fig. 74).

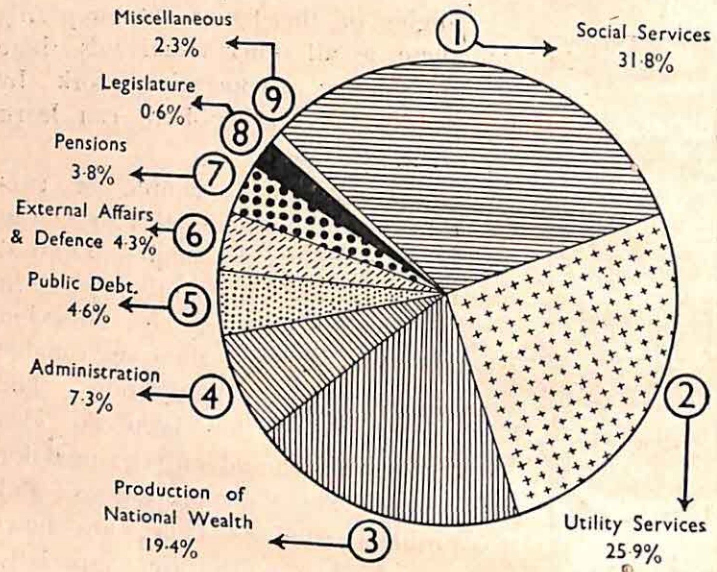


Fig. 71. Example of a sector diagram.

While this is not the place to discuss graphical methods in great detail, it is well to point out a few simple ideas which will be of use in several connexions. It is a good idea to set the same data out by more than one method. This is shown in relation to population statistics in Fig. 75, which shows five methods of presentation:

1. Tabulation of data for different years.
2. Pictorial presentation.
3. Bar graphs forming a histogram.
4. Graph of totals against time.

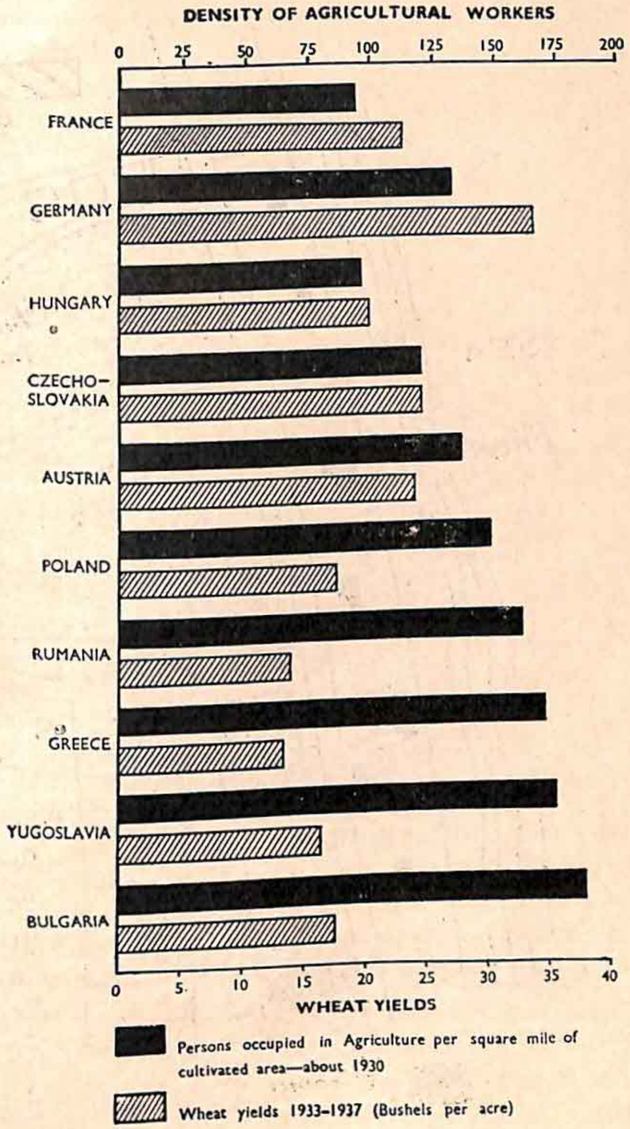


Fig. 72. A typical bar graph.

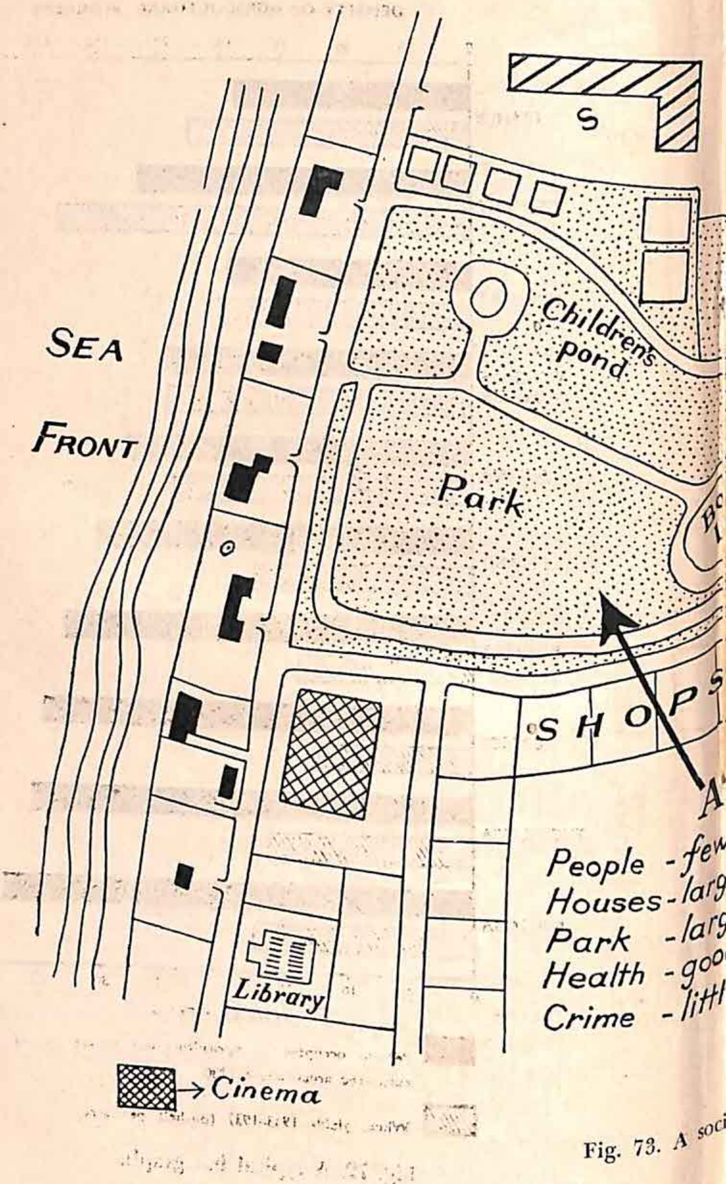

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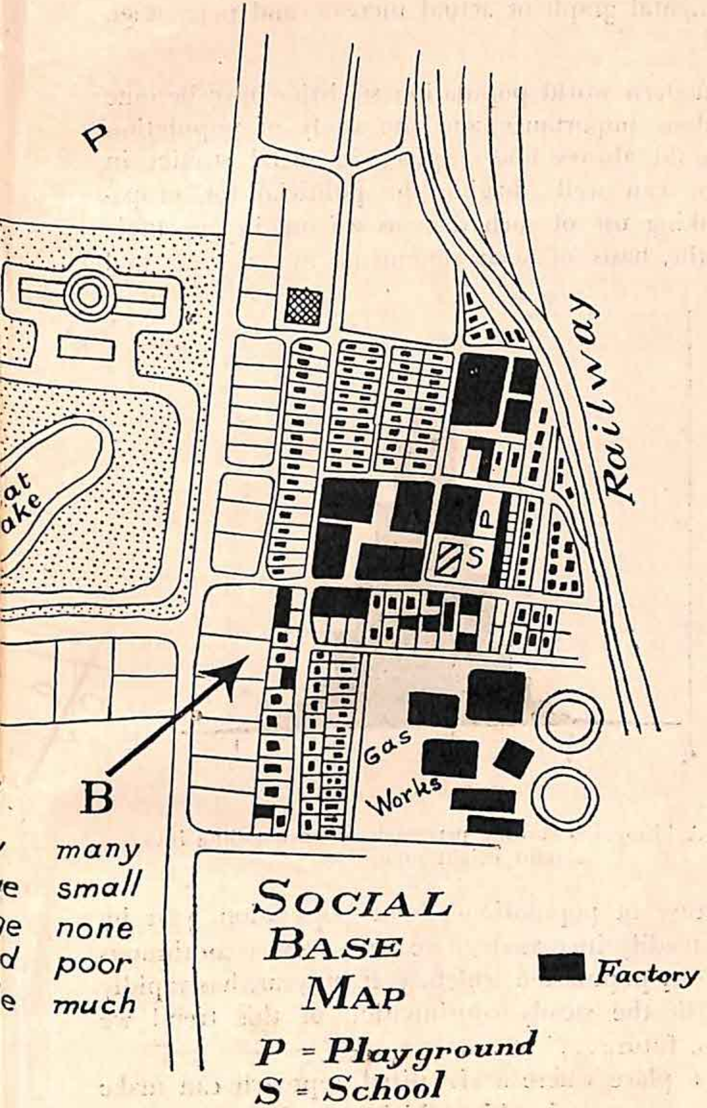
Fig. 73. A soci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SOCIAL
BASE
MAP
Factory
P = Playground
S = School

ial base map.

5. Incremental graph of actual increase and percentage increase.

In the modern world population statistics have become of tremendous importance and the study of population change should always find a place in social studies in school. One can well imagine the politician or propagandist making use of such data as we use in our table above as the basis of such statements as 'a great and rapid increase of population', 'our population, year by year, has steadily increased', 'we have seen a continuous growth in our population which, year by year, has rapidly grown. With the steady continuation of this trend we shall in the future . . .' etc.

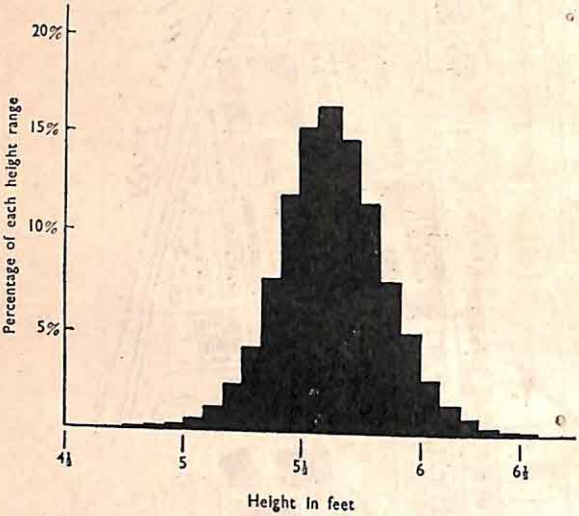
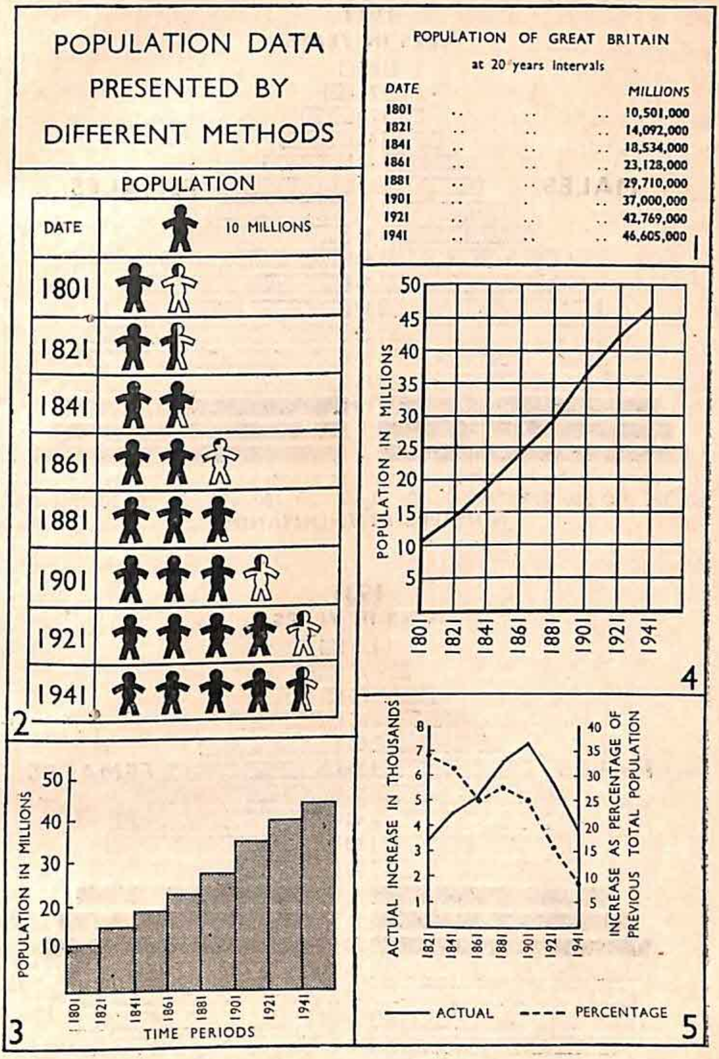


Fig. 74. A histogram showing percentage of men falling into certain height groups.

Here is a place where a visualized approach can make clear at once a relationship which may be overlooked.



POPULATION OF GREAT BRITAIN
at 20 years intervals

DATE	MILLIONS
1801	10,501,000
1821	14,092,000
1841	18,534,000
1861	23,128,000
1881	29,710,000
1901	37,000,000
1921	42,769,000
1941	46,605,000

Fig. 75. Different methods of showing population data.

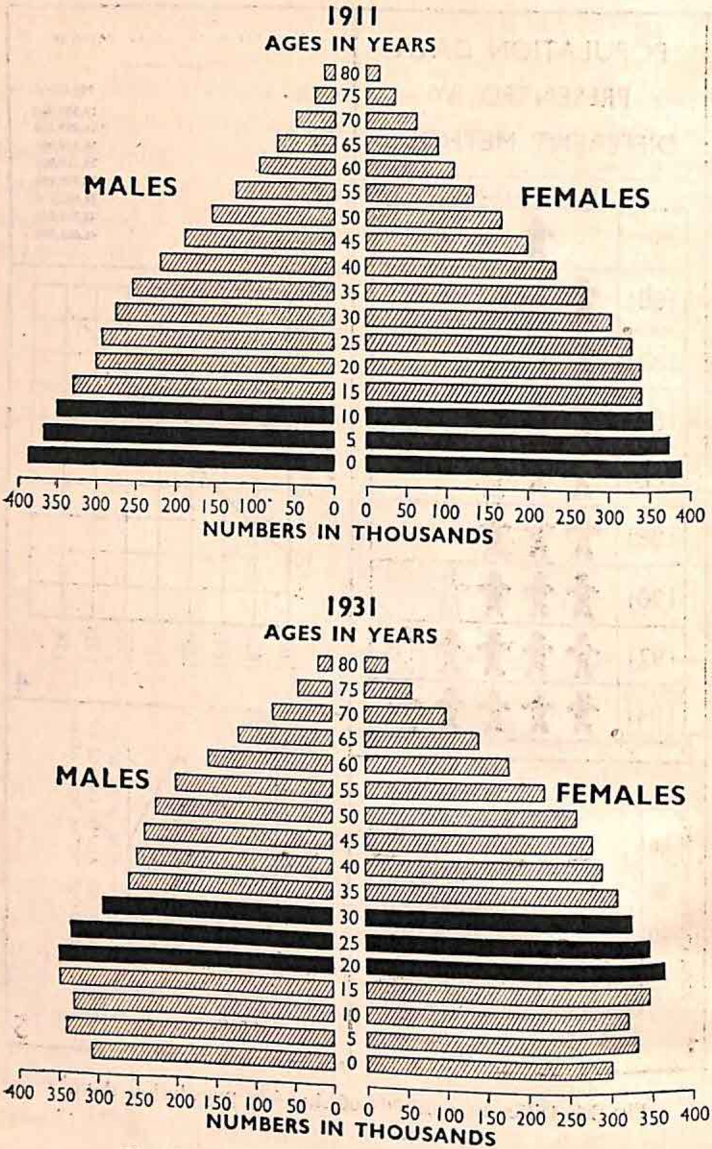


Fig. 76. Population pyramids for two dates.

The population has increased from period to period, but the *rate* of the increase has *decreased*. The population has been getting bigger and bigger, but has been doing so at a slower and slower rate. This point, simple enough to the trained and informed mind, presents difficulty to even the senior pupil or man in the street.

Populations are characterized not merely by their totals but by the proportions of people of different ages at different dates and by the relative numbers of the two sexes. To show this the population pyramid is used. A series of pyramids drawn for different periods provides a visual demonstration of a telling kind, as may be seen in Fig. 76. The same data could not so readily be shown by an ordinary graph.

The Flannelgraph or Flannelboard

One of the most effective two-dimensional visual aids is the flannelboard or flannelgraph. This is cheap and easy to make and use and has a wide range of applications. It has proved its value in education at almost every level and offers an excellent introduction to the methods of visual education for those taking initial steps.

The method derives its name from the use of flannel, a textile containing wool fibres which give a roughness to the surface. This roughness is known as the ' nap '. This nap is such that when brought into contact with each other two pieces of flannel tend to stick together. This capacity of adherence is the basis of the flannelboard.

The flannelboard is a flat board on the surface of which a sheet of flannel has been stretched and glued flat. It is essential that the surface is quite flat. If the base is of plywood it should be screwed to a framework of battens to prevent warping. A well-built blackboard, though rather heavy, makes a good base. Whatever is used the surface must be flat, thus cracks and crevices should be filled (with a mixture of glue and sawdust) and the surface worked flat. The flannel should be stretched out and tacked into position along one edge of the board, glue applied and the textile stretched out and 'wiped' into position on the glue. Allow to dry completely, trim the edges neatly and apply protective strips if thought necessary.

A suitable size for a flannelboard is 4 × 3 feet (120 × 90cm). If smaller than this the area is insufficient. If greater, the board becomes too heavy.

The board can be supported upon a blackboard easel for use, or it can be hung on a wall. In the latter case a wooden strip should be so placed as to cause the lower edge of the board to stand further away from the wall than the top edge. The board is thus not vertical but slightly tilted. This reduces the chance that gravitational force will overcome the adherence between the two textile surfaces.

Diagrams, lettering and other symbols and pictures can be caused to adhere to the board by backing them with flannel, or by cutting them out of flannel. For example a piece of white flannel might be cut to show the greatly magnified shape of a biological cell, e.g. amoeba. When pressed on to the flannelgraph it will stick in place. Other pieces in other colours (those of the stains used in a microslide would be excellent) may then be cut to represent the nucleus and other cellular structures. As they are referred to they can be stuck into position.

In some cases it may be necessary to make diagrams, labels or pictorial material for use on the flannelgraph. In such cases the drawing should be prepared on a fairly stiff paper to which a backing of flannel has been glued. The drawing is then cut out for use on the board. In this way almost anything which can be illustrated on the blackboard can also be handled by the flannelgraph method. Although the materials have to be prepared beforehand, and some time and effort are involved, they can be used many times. Moreover, with a little forethought many items can be made to fulfil several purposes. This is especially so in the case of letters, figures and symbols. As these are likely to be used often they should be prepared on a stiff paper base.

In using the flannelgraph it is essential to have the required materials not only prepared beforehand, but so arranged as to be ready for immediate use. Thus each 'subject' should be kept as a separate unit, in a box or envelope. Only those elements with multiple purposes should be kept in a general box.

In the early school years the flannelgraph is likely to be used only for simple illustration, as in a story. It has however also been found useful in teaching numbers and reading, or where a pupil is asked to show something on a board for the rest of the class to see. In the later years its functions are both more numerous and more complex. Thus the flannelboard can be operated as an overlay diagram in the teaching of biology or geography, for teaching about chemical reactions, atomic structure, molecular structure and so on. It also has applications in the arts subjects. Indeed the real limitations to its use lie not in the instrument itself, but in the ingenuity of its users.

Those who wish to try out the method should note the following practical points :

1. The board can be of wood, plywood, or a matrix such as Masonite. It should be built on a batten frame to prevent warping. The flannel which is applied to this as the base should be of medium to good quality, glued flat

and wrinkle-free. Black flannel is convenient for the base as it provides a contrast for other colours.

2. For small pieces which need to retain their shape in order to fit together neatly a good quality flannel is desirable. If they are to be used frequently—say in the case of H, C, O atoms for showing chemical structure and in the 'links' between items, a thin felt can be used.

3. For backing behind paper labels, or where the pictorial material is painted on paper, a very cheap flannel or cheap lint can be used, on which the pictures are then pasted.

4. Have the board at a slight angle, as a blackboard on an easel usually is. This helps to retain the pieces in place.

5. Restore the nap by brushing the flannelboard with a brush.

6. For sticking flannel to paper a stiff paste is always preferable to a thin medium. A thick flour paste will be found satisfactory. Put a small amount of flour in a saucepan or tin, add a little water and stir to a smooth paste. Add more water, warm and stir until boiling. The paste will thicken as it cools and it can even be used when cold.

7. For quick repairs, even during a lesson, it is best to use one of the quick-drying cements which are based in many cases on amyl acetate solutions.

8. Store all prepared materials flat in folders or envelopes and protect them from damp and insects. Label the envelope.

The Magnetic Board

The property of magnetic attraction has been used in the idea of the 'magnetic board'. This can be made very easily and in some ways is similar to the flannelboard.

First a flat base is needed, of wood, ply or other matrix material, held flat on a well-built frame. To this, instead of flannel, a sheet of tin (actually tinned iron sheet) is applied, being held in place with small screws.

The materials to be used in teaching, cut-outs, symbols, lettering, are made from stiff paper or thin cardboard. To each of them, according to relative size, one or more small magnets are attached. It is these which will hold the symbol or letter in place on the board.

Small magnets can usually be purchased from commercial sources. While the old-fashioned bar magnets can be obtained, it is preferable to use those made of modern steels which are possessed of exceptional magnetic qualities. However, even if no magnet can be purchased it is possible to make small ones. For this purpose short lengths of steel knitting needle, or small-diameter steel rod, or flat strips should be prepared. They can be magnetized either by 'stroking' with a large magnet or by placing them in the field of a coil through which a current is passed.

The magnetic pieces can be taped in place, held in a slot or by an adhesive at the back of the cut-out or symbol.

XI

VISUAL MATERIALS IN THREE DIMENSIONS

Our ability to see in three dimensions depends upon our possession of binocular vision. Experimental work shows that this ability is at first lacking or imperfect and that it rapidly improves with growth and age. However, even in middle and later childhood 'spatial perception'—visualizing in three dimensions—is still in the process of perfection and presents a number of problems which are not yet fully understood. Studies in this field have shown that individuals differ in their ability to perceive differences of form and shape in three-dimensional figures. From the teaching angle this means that difficulties of understanding arise. For example, from everyday experience we are aware that many pupils find it difficult to imagine what a solid body will look like if seen from an unusual angle. Similarly they are often unable to imagine what a cross-section would appear like. Instances of this kind are met with in studies such as botany, zoology, woodwork, geography and the like—and the difficulties are made worse because we either make too little use of illustrative materials or else depend upon two-dimensional pictures to explain a three-dimensional problem.

The task for the teacher, then, is to find methods of presentation which will meet these difficulties. One which is obvious, though seldom fully explored, is to give far greater attention to practical work, to the handling and manipulation of objects and materials. Because we have so greatly neglected this, education has become abstract and remote from realities; thus to the original difficulty

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of spatial perception we have added the further one of lack of practical experience. There are two other major lines of approach, through specially prepared pictorial materials and through models and modelling, to which we now turn.

One pictorial approach to this problem is through overlay pictures which are known to most of us from the 'mannikin' printed in books on elementary physiology and hygiene. This consists of a basic picture showing internal structure over which paper flaps can be folded; on each of these flaps other structures are shown, and on the top or outer one the body surface. Such figures are quite easy to make, as is shown in Fig. 77. In this figure A is the external view; note the black extension pieces which act as hinges. B shows the outside folded up to display the viscera painted on the inner flap. C shows the inner flap turned down to reveal air bladder, backbone, etc.

A useful device for representing three-dimensional conditions on a two-dimensional figure is some form of perspective drawing. Some reference has already been made to this in an introductory manner, but it is now desirable to give it greater attention. Every teacher should ensure that he has some understanding of the main principles of perspective which, for our elementary purposes here, can be put in a few words. The main points are that objects appear relatively smaller the further they are from the observer and that parallel lines appear to recede from the observer to meet at a distant vanishing point. These facts can be verified by the simple process of standing on a railway bridge and looking down the line. The telegraph poles and signal pillars appear to get shorter and shorter in the distance—while the track lines appear to get closer and closer together, Those who are not familiar with simple perspective drawings should do some practice work by drawing a

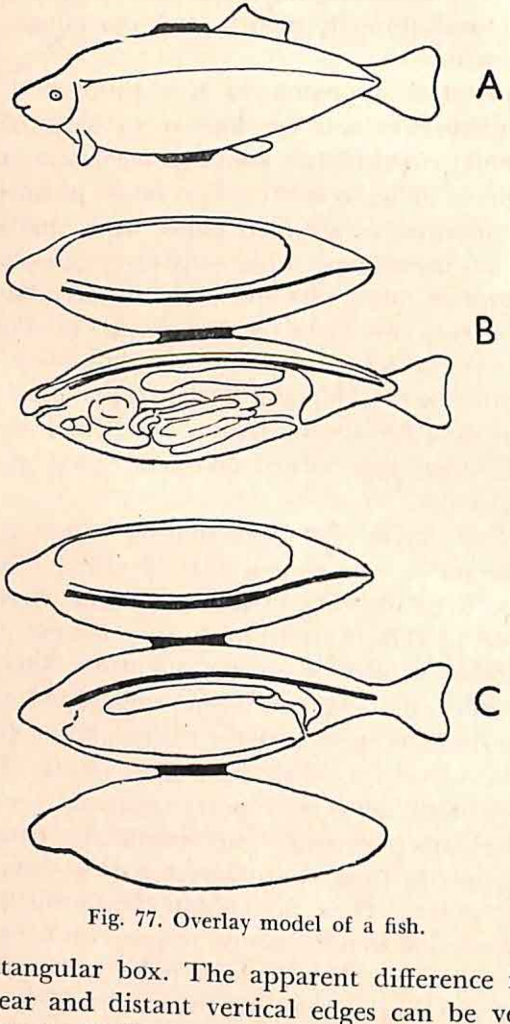


Fig. 77. Overlay model of a fish.

large rectangular box. The apparent difference in height of the near and distant vertical edges can be verified by measurement. Hold a pencil vertically at arm's length with its top apparently level with the top of the near edge of the box and mark the lower level of this with the thumb on the pencil. Now align the pencil against the far edge with the thumb apparently marking the lower limit; observation will show that the pencil top appears to be higher than the top of this distant edge—in other words this appears to be shorter than the nearer edge. A drawing of a cubical box, seen in simple perspective, is shown in Fig. 78. In A it is lying well below eye level, in B just below eye level, in C well above eye level and in D just above eye level. Exactly the same principles are applied to the making of perspective drawings of any solid body, such as a house or a row of houses—one only has to 'keep one's head' and treat the whole as a simple box. Some stages in making such a drawing are shown in Fig. 79.

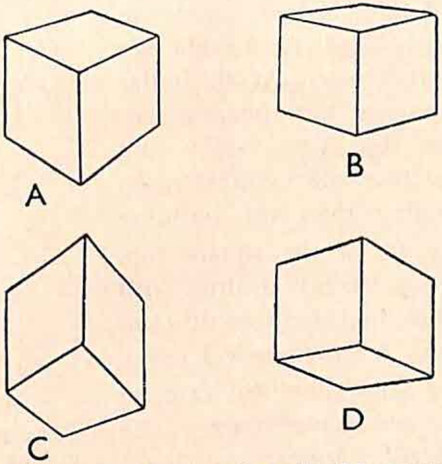


Fig. 78. Perspective drawing of a cubical box seen from different levels.

Because a grasp of the principles of simple perspective is so useful in relation to making visual aids it is wise to take the matter a little further. Imagine a situation in which an observer is able to stand in successive positions at the bottom, in the middle and on the top of a tall building and look at a nearby square tower which is shorter than the observer's building. Looking up from the bottom, A in Fig. 80, he sees the top edges of the tower apparently sloping downwards, while the bottom edges appear to slope upwards, and he cannot see the top of the tower. At B similar conditions obtain, but the apparent slope of the top edges is less and that of the lower edges greater. At C he is higher than the building and is able to see its square top. Assuming that we are dealing with a very tall building there would even be a tendency for the vertical edges, falling away from him, to have an appearance of convergence. The human observer appears to make considerable correction for this, but it becomes a very marked feature in a photograph taken in these conditions.

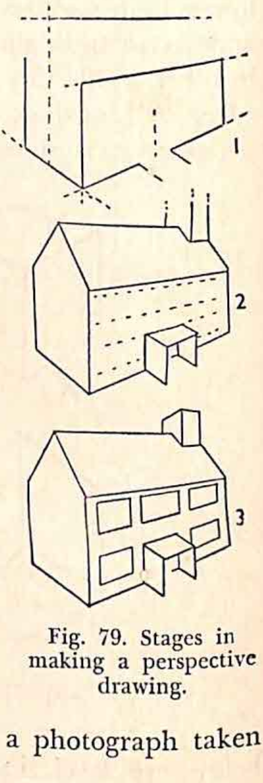


Fig. 79. Stages in making a perspective drawing.

In general there are three main rules to follow:

1. Perspective projections of vertical lines are vertical in the plane of the picture in which they are drawn, unless the observer is looking from above downwards, or from below upwards, at a very tall structure.

2. Perspective projections of the horizontal edges of

vertical faces which are parallel to the plane of the picture (i.e. which the observer is facing at right angles) are themselves horizontal.

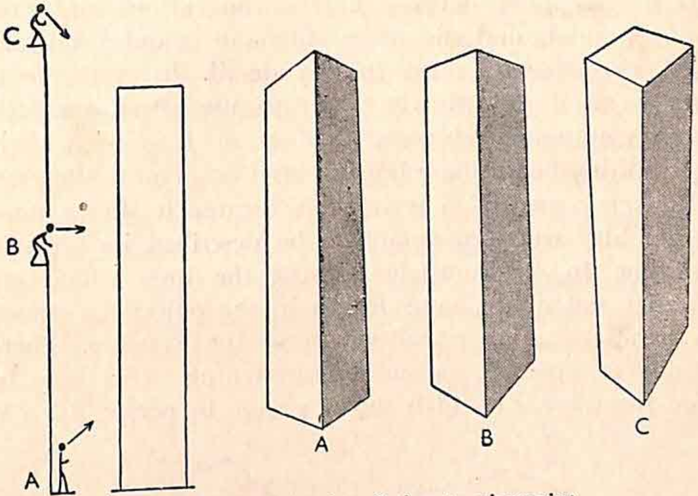


Fig. 80. Perspective in relation to viewpoint.

3. Perspective projections of horizontal lines (e.g. top and bottom edges of a vertical face) which are parallel to each other but at an angle of less than 90° to the observer, appear to converge to a vanishing point which lies at the same height above the base as does the position of the observer.

While there are other rules of perspective drawing these three cover the more important points and, once they are grasped, the rest will follow with practice. It should be noted that the imaginary lines which are drawn from points on the object to the plane of the drawing are known as *projectors*. In perspective projection the projectors converge to meet at a point and are thus known as *radial projectors*.

There are special purposes, for example in connexion with architectural drawings, where simple perspective is not entirely suitable. As a result certain other formalized modes have been developed. The conventions and procedures which underlie these are more complex but we need not describe them in any detail. It would however be well for all who want to use visual methods of presentation to become familiar at least with their possibilities, hence the following brief notes on the matter.

Isometric projection is valuable because it allows most, if not all, structural details to be described in a single drawing. In an isometric drawing the lines which are parallel and of the same length in the object are drawn as parallel and of equal length in the drawing. There is no convergence and no foreshortening. This may be seen from Fig. 81 which shows a cube in perspective (A) and isometric projection (B). In the latter the cube stands with one diagonal vertical so that the cube is seen in plan from above.

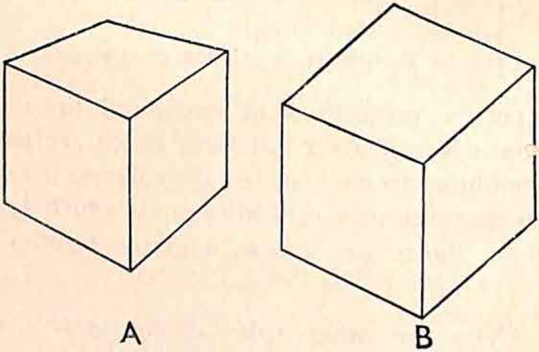


Fig. 81. Perspective (A) and isometric (B) drawings compared.

Oblique parallel projection is easy to construct and has the marked advantage that circles can be drawn as such and not as ellipses, which is the case in isometric projection. Fig. 82 shows an example. The structure was first drawn in full face view and projection lines drawn in at 30° to the horizontal. True widths are marked along these projectors.

Axometric projection uses axes which are not at the same angle to the plane of projection, and the diagonal axis on which the solid 'stands' is not vertical. The choice of angles is arbitrary and, in theory, almost limitless. In practice, however, only a certain range of views is acceptable to the eye. In general axometric projection is more acceptable than isometric because the view it gives can be made approximately more closely to that seen from the normal eye position. Isometric views tend to be high angle views while axometric views can be low angle views, with just enough tilt to show the top surfaces of a solid.

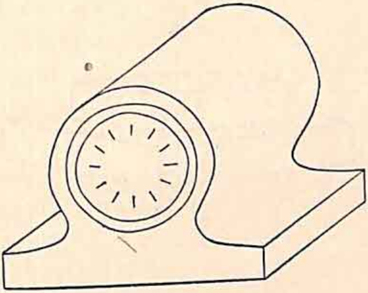


Fig. 82. Oblique parallel projection of a clock.

In Fig. 83 two square blocks, one lying on the other, have been drawn in three ways. A shows a side view, an example of orthographic projection. B shows a view with the object just below eye-level, or at eye-level with a slight tilt towards the observer, a case of axometric projection. C carries the tilting process further so that more of the upper surface is visible, as in isometric projection.

To those without training in solid geometrical drawing this description of certain elementary projection techniques may seem elaborate. This is not so, however, and the whole matter can be understood easily if some practical work is done. It is important to gain some understanding and skill because one can then more easily undertake the preparation of diagrams which achieve the illusion of solidity. In particular one can begin to make stereograms, drawings which make use of these projection techniques coupled with other devices, such as showing certain surfaces cut away to show internal structure. Stereograms are so called because they present an attempt to achieve the appearance of solidity which comes from binocular vision, on which stereoscopic perception depends. They can be based on simple perspective, oblique parallel projection, isometric or axometric projection. For the untrained beginner oblique parallel projection is perhaps the simplest style though it does not (at least to the better informed) carry the same conviction as a less artificial projection, such as axometric or even simple perspective.

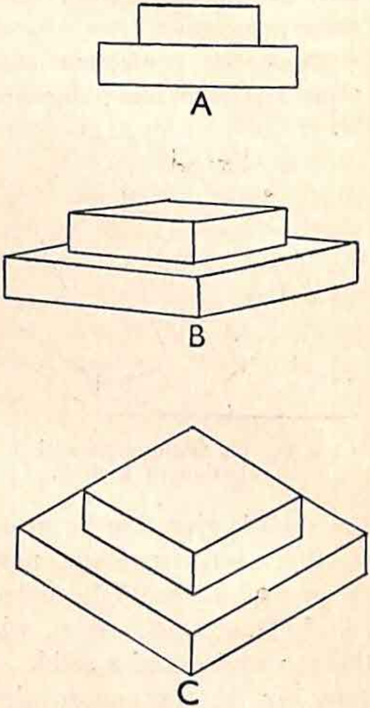


Fig. 83. Three types of projection.

Stereograms are useful for dealing with the relationships of solid structures in such subjects as physical geography, botany, zoology and the like. For those who are able to make them they are useful in other directions, for example in illustrating architecture, house design, stage and theatre layout and so on. Their value to the teacher and pupil, together with some hints on making a stereogram of a simple kind, can be shown by a series of drawings as in Fig. 84. This example deals with the structure of the earthworm in a simplified manner. The pupil's understanding of this can be acquired by dissection and from the study of sections. Although the dissection is simple many pupils fail to perform it well and many more

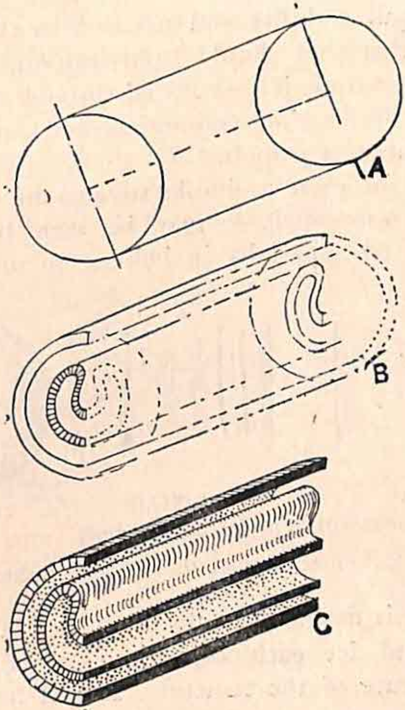
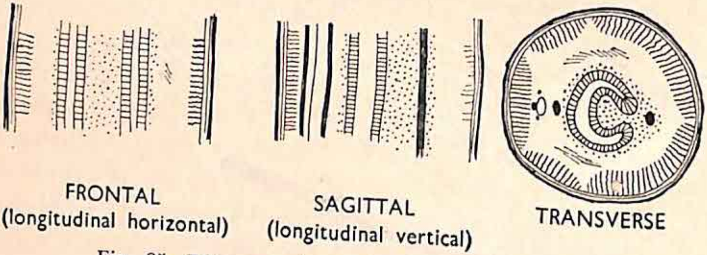


Fig. 84. Stages in drawing a simple stereogram.

find difficulty in re-interpreting what they see (distorted and flattened in a dissection) into a three-dimensional structural concept. Microscopic sections, usually available in transverse and sagittal (longitudinal vertical) planes offer some help, which is extended where frontal (longitudinal horizontal) sections are available. To synthesize a picture of the solid structure from these three sections, however, requires ability and practice, so that pupils do not get all that they should from sections. More understanding might come if they traced through a whole series of sections; this is time consuming—and such a series is seldom available in schools.

The value of even a simple stereogram, as compared with microscopic sections, may be seen by comparing Figs. 84 and 85, especially in helping to understand the typhlosole. It is desirable to use both methods, as well as dissection, and let each contribute to building up a complete picture of the structure. It will be seen that a simple stereogram is not difficult to prepare by working stage by stage as shown in Fig. 84.



FRONTAL (longitudinal horizontal)
SAGITTAL (longitudinal vertical)
TRANSVERSE

Fig. 85. Three sections through an earthworm.

While it is true that skill in drawing is of great value to the teacher it is also true that anybody can make visual aid materials of this kind by merely following out the mechanical operations involved. However elaborate they appear, drawings of this kind merely depend upon an understanding of the construction involved and some patient work with pencil, pen and brush. Use should be made of the pupils themselves in this kind of work. Its novelty makes it interesting, this leads to effort—and effort to learning.

There are situations in which the stereogram may not meet all the difficulties experienced by the pupil in understanding structural relationships. A further device which will be helpful here is the 'exploded view'—a drawing which shows an object broken down into its components which are displaced in space, but still retaining some degree of positional relationship. Drawings of this kind are essentially stereograms. A simple example is shown

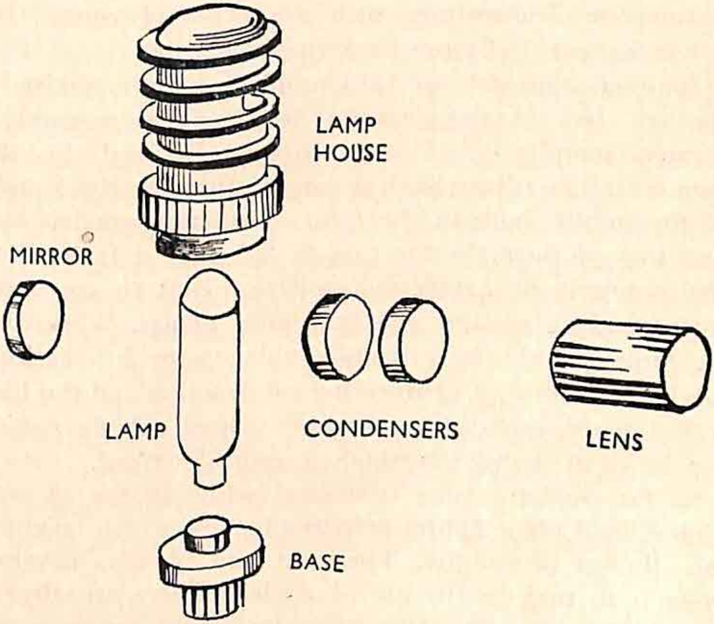


Fig 86. An 'exploded view' to show relationship of parts in a film projector,

in Fig. 86. Unless they are made carefully, with a proper regard for the effects of perspective and different positions of observation, they can be misleading. In any case the pupil must be helped to understand the conventions used, being helped by the use of additive materials–guide lines, labels, matching of paired or contiguous surfaces and so on.

In some cases, where complexity is very marked and where the structure involves a large number of different elements, an exploded view would be almost as confusing as the results of an explosion. This difficulty could be overcome by using a series of exploded views in which the object is gradually broken down into its components, a step-by-step process which is easier to comprehend than a complete dismantling. Such a process, of course, involves a great deal more work in preparation.

Another approach to this problem of complexity is through the 'cut-away drawing' based on a stereogram of greater complexity. This is frequently used in the demonstration of mechanical construction for the benefit of the public, both in the form of cut-away models and drawings of them. In the case of drawings it is usual to use isometric or axometric projection and to cut away surfaces along vertical and horizontal planes. While this technique would have considerable value in teaching mechanical drawing, engineering construction and the like, it has fewer applications to other school subjects which can be dealt with by methods already described.

So far we have been concerned with the use of two-dimensional plane figures prepared in ways which heighten the illusion of solidity. The next and obvious development is to turn to the use of models. These are already used by teachers, especially in junior school project work, and in the biological sciences, geography and the like.

The basic intention, in most cases, is to demonstrate what cannot be readily brought to the classroom, because it is either too large or too rare, and hence too costly. Models are also used to present what, in the original, is microscopic or at least very small. These are legitimate uses of models, but we must not lose sight of the contribution which the model can make to understanding by the simplification of what is complex, to the appreciation of relationships and to the understanding of processes and movements. Nor must we overlook the contribution which comes from manipulation and handling.

It may be convenient to give a brief description of the kinds of models which are most readily available for the teacher and which are likely to be of most use to him.

Impressionistic models are those made to illustrate a point in structure or function without necessarily reflecting the actuality of structure.

Representational models reflect, to a lesser or greater degree, the real structures and processes. It may be convenient to point out that we have two major approaches to the representational model: (i) the simplified model which looks like the real thing; (ii) the scale model which, in virtue of being built with the greatest accuracy to a reduced scale is, to all intents and purposes, the real thing in miniature.

Another way of classifying models is to treat them as: (i) non-working models; (ii) working models (these terms are self-explanatory).

It might be useful to mention here another classification:

1. Bas-relief models, carved or cast in low relief.
2. Full-relief models, which are three-dimensional,

3. Take-apart models which can be taken down and reassembled.

The wide variety of models and of model-making methods renders it difficult to give a concise account of the place and preparation of the model in teaching. The following brief guide should, however, be sufficient to help the beginner to make a start; once that is done the rest will come from experience.

In connexion with any subject where structural problems arise it should be the practice to have readily available one or more of the plastic modelling materials (see p. 146). With these at hand both teacher and pupil can at once make a model to elucidate the problem—a habit which experience has already proved to be of value, especially in the biological sciences. It is an interesting point that pupils can often reconstruct something in solid materials long before they are able to make satisfactory drawings of it. Most of the models made under these conditions will be simple and ephemeral, but the material can, in some cases, be used over and over again, for example the non-setting clays. Sometimes a model is worth keeping. If it has been made with potter's or artist's clay it can be fired and so hardened. A cheap mock-up for firing consists of a large biscuit tin supported on a tripod and heated by a Bunsen or wood fire below it.

Much simple modelling can be done with the hands alone. For more elaborate purposes or where fine detail is to be shown, a few simple tools are required. These can be made from hardwood which is well polished with

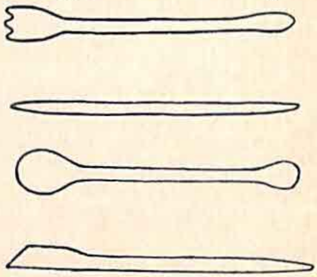


Fig. 87. Wooden spatulas for modelling.

glass-paper. Some suitable shapes are shown in Fig. 87.

The actual making of a model is largely a matter of common sense and, while easy to do, is less easy to describe. It is wise to make a rough sketch of what is required with some indications about the sizes. As an example of a simple model take a bas-relief of a cross-section across an earthworm in which the stages would be:

1. Make a rough sketch, full size, of what is wanted.
2. Make a clay disc of appropriate size.
3. Scratch lightly on the surface the necessary outlines of details.
4. Work up the surface by excavating or building up; get the surfaces smooth and clean.
5. Add details by scratching or moulding with hand tools and get the surface as smooth as possible.
6. Add differentiation effects by criss-cross lines, dotting etc.
7. Paint surface with two coats of size—a thin solution of glue.
8. Distinguish between the various structures by painting with oil or water-paint of different colours.
9. Finish with a coat of varnish.

For more elaborate structures one must work not in bas-relief but in the full dimensions and so aim at a greater degree of reality. We may take as an example the making of a model of a frog's heart. The pupil finds it difficult to understand this because it is small and rather complicated; a model, ten times the original size, is a great help. Such a model should show the internal structure and also as much external structure as possible. Thus it must be fully three-dimensional and cannot be made merely on the surface of a flat disc. The stages in the process need not be described in detail because they will be very similar to those in the list given above—and the main points in the practical process are very simple. For example, one starts with a solid clay mass moulded roughly to shape and works first at the internal surface and structures. When these are completed the whole thing is turned over and the outer form and details are worked in. The main difficulty is that of making the walls thin without penetrating them—fortunately repair is easy while the clay is still malleable.

It may sometimes be necessary to make several copies of one model. These could all be carved in clay and made as nearly alike as possible but it would be better, especially if exact copies were required, to work in plaster of Paris with the mould-and-cast method. The main stages in this method are as shown in Fig. 88.

1. Making the original model which can be in artist's clay, cement, wood, etc.
2. Making a mould in plaster of Paris : this is a 'negative' of the original.
3. Casting a copy in the mould to reproduce the 'positive' features of the original.

The process is far simpler to do than to describe, and pupils soon learn how to carry it out. The beginner should pay attention to the following precautions.

1. Start with something simple, such as a bas-relief.
2. Use a slow-setting plaster of Paris.
3. Allow it to set hard before attempting to remove cast or mould.
4. Use a soapy solution on the surfaces to prevent sticking.
5. Be certain that there are no undercut surfaces. The reason for this may be seen in Fig. 88 which shows

a section through a casting box with cast and mould. The cast will have to be lifted up from the mould ; where there is no undercut this is simple, but where an undercut surface is present it is impossible unless the mould is broken.

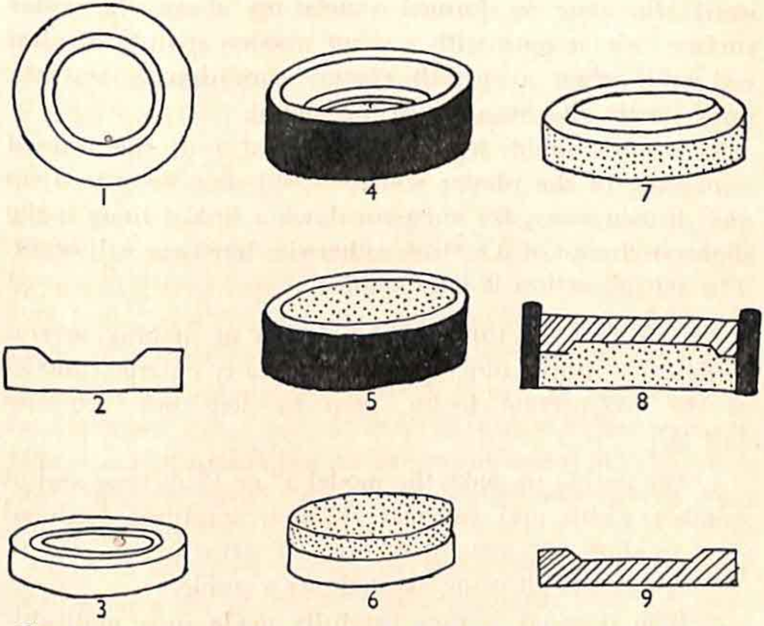


Fig. 88. Making a plaster cast. 1, 2, 3 show the original to be copied; 4, 5, 6 show the making of the mould; 7, 8, 9 show the making of the cast. The casting box is made by placing a plastic wall around the original.

6. Have everything ready and in order and only mix up the plaster at the moment it is required. Some experience is needed to estimate how much must be prepared and in what proportion the powder and water should be taken. The aim is to produce a thick creamy solution quite free of lumps and air bubbles which will *pour freely*–if it is too thick it will flow slowly and

probably its viscosity will prevent it from running into all parts of the mould before setting begins.

7. The easiest way to prepare the plaster is by putting the estimated amount of water into a beaker or basin and then quickly pouring the dry powder into the water until the cone so formed stands up above the water surface. Stir at once with a clean wooden spatula or glass rod and, when a smooth creamy condition is reached, pour slowly and evenly into the mould.

8. Water should at once be poured into the unused remainder of the plaster which should then be stirred up and thrown away. *Do not* pour down a sink if there is the slightest chance of it setting—otherwise blockage will occur. The setting action is irreversible.

Let us now go through the details of making several copies of a simple object such as a greatly enlarged model of the cœlenterate hydra. Step by step our processes will be :

1. We decide to make the model 5″ or 13cm long and of suitable width and to treat it as a simplified sectional view to show the general features of structure.

2. A full-size drawing is made as a guide.

3. The original is now carefully made in a malleable plastic, either a proprietory material or artist's clay. The surface of the section is flat and lies in a single plane, the cavity of the body and tentacle is scooped out and cellular structure suggested by drawing lines on the sectioned surfaces. This original must have no undercut surfaces and must be allowed to dry hard if made of clay.

4. We now need a box which is made, in this case, by the simple process of taking a long ribbon of plasticine of a width somewhat greater than the thickness of our original model. This ribbon is carefully placed around

the edge of our model to make a kind of solid fence all around it—thus we have a hydra-shaped box!

5. A little soap solution (rather a lot of soap and little water) or a thin oil is placed at hand with a brush or a wad of cotton wool or even of soft paper.

6. The plaster of Paris is now made up, as already described.

7. Quickly brush the model over with soap or oil and at once pour the plaster into the mould and allow to set hard.

8. When hardening is complete, peel away the ribbon sides and carefully separate the copy from the original. This is a negative and will now be used as our mould for making true copies.

9. Look over the mould and, with careful use of a knife, accentuate any of the lines which were scratched on.

10. Give the mould a coat of glue size and allow it to dry and then give a coat of quick-drying varnish. (These are advisable but by no means essential.)

11. Make a 'fence' round the mould and have a soap solution ready.

12. Mix up more plaster of Paris, brush soap on the mould, pour the plaster and allow it to set.

13. Remove the fence and separate the cast from the mould.

14. The cast is a copy of the original. It should be sized, painted and varnished.

15. Repeat the casting in the mould to produce the required number of copies.

Having acquired an understanding of the method and experience of handling the materials we can proceed to something more elaborate—of which we give three examples.

Let us suppose that we have a rather rare object, say a fossil shell, which would be a valuable piece of evidence in teaching but which is too precious to expose to the risks of handling by a large class. To make a copy of this involves a new problem because we cannot work with an exposed flat surface cast in a simple open mould. Here we shall have to make our mould in two parts which, when put together enclose a cavity the shape of the original. The procedure will be as follows:

1. Make a wooden casting-box into which the original will fit with about an inch of clearance all round. Use screws.

2. Pour a plaster mixture into the box and allow it to *begin* to harden slightly.

3. Paint the fossil over with soapy water and then press it down into the plaster in the casting-box until it is half buried in the hardening plaster. Leave the fossil in position and allow the plaster to dry hard.

4. Take freshly made plaster, hold a pencil upright on the fossil, paint the lower plaster surface with soap or oil and then pour plaster round and over the fossil until the box is full. Leave the pencil in place and let the plaster harden.

5. Unscrew one side of the box, lever out the whole contents, lever off the one half of the plaster block along the line of separation between the two halves of the mould. Lift out the fossil. One now has a mould made of two halves.

6. Make up more plaster of a slightly greater fluidity than before so that it will pour more easily.

7. The plaster is poured steadily through the hole left in the upper mould by the pencil. Air will be displaced through the same hole which will finally fill with plaster.

8. When hard remove the moulds from the casting-box, prise away the lower mould to expose the lower half of the cast. Remove the cast from the upper mould by tapping the core which has formed in the pencil hole.
9. Pare away the core flush with the surface of the cast and finish as nearly as possible to the surface structure.
10. Size, paint, varnish.

The only difficulty likely to be experienced, and then probably only with careless pouring, is the filling of the pencil hole with plaster before the mould is full. This can usually be overcome by having two holes, one for pouring and a smaller one, made with a knitting needle, as an air vent.

It is not always possible to avoid undercut surfaces. These can be dealt with, if the degree of undercut is slight, by using a slightly elastic material to make the mould so that it will stretch or deform enough for the cast to be removed and then go back to shape. The proprietory materials made for use by dental surgeons in casting dentures will be found suitable for this.

Finally we must be prepared to make copies of larger objects of a shape which does not allow the use of one mould or even of two half-moulds. Such cases should be avoided if possible, but where they have to be undertaken one must work with a method based on the double-mould technique described above—the difference being that the mould may have to consist of several pieces. Where only one copy is required the mould can be broken to remove the cast—but it may not be easy to make the mould to start with and remove the original from it.

The process can be explained in a few stages as follows:

1. Make a suitable casting-box.

2. Place the original to be copied on the floor of the box.

3. Divide the floor of the box, as seen in plan view, into two or more compartments with a sheet of plasticine. This must be cut and worked to shape so that it fits the floor and side of the casting-box and the external surface of the original. Its height must be determined in relation to the shape of the original.

4. Pour plaster into the compartments on each side and to the same height as the dividing walls, and allow to harden.

5. Make *horizontal* plasticine divisions between the walls of the box and the object.

6. Add other vertical divisions if necessary.

7. Pour in more plaster of Paris and allow to harden.

8. Unscrew the casting-box and remove the mould, which will be in several pieces.

9. Rebuild the casting-box but add top and leave bottom open.

10. Reassemble the mould, putting in plasticine sheets in the original positions and building it upside down.

11. Cast a copy by pouring plaster into the opening which was originally at the base where the object stood on the floor of the box.

12. After hardening, unscrew the side of the box and remove the mould to free the cast ; more copies are made by repetition ; trim with a knife, size, paint and varnish.

This process is less elaborate than it sounds, but it is somewhat lengthy and should only be undertaken when nothing else is appropriate. Its chief advantage lies in the possibility of making several copies from one mould. Where a single model only will meet the teacher's needs it should be made in artist's clay or some other medium which is easy to work.

Papier mâché has the advantage of being easily worked and models made from it will not break very easily—but it is difficult to work it to accurate form or to add very fine details on its surface. It consists of paper pulp made preferably as follows :

1. Tear up a large amount of newspaper into small fragments.
2. Place in a large bowl and add a little water ; press the paper down and add water until *all* the paper is moist.
3. Knead and squeeze the paper with the hands to break up the pieces.
4. Make up a thin solution of size by adding glue powder to warm water in the proportions of 1 oz. (28.4gm) of glue to 20 oz. (568gm) of water.
5. Put the size in a can or saucepan on a slow fire and take the paper pulp in handfuls, squeeze out water and put the pulp into the size.
6. Break up the paper pulp, which has been squeezed into balls, and allow the mixture to simmer. Stir and work the mass to get an even consistency ; continue until the mixture is in a thick viscous condition.
7. Build the model from the pulp with the hands by squeezing to shape, blotting off the surplus fluid from the surface which can be smoothed with a spoon handle or spatula. The model can be hollow or worked up on a core of clay or even a wad of cotton wool.
8. Allow the model to dry hard, then sandpaper the surface if it is necessary to get a smooth finish.
9. Paint as required and give a final varnish coat.

Teachers are nowadays also able to make use of a number of productions and developments which, though aimed at play and entertainment for children, are often of considerable educational value, both direct and indirect.

The variety of material available is so great that selective reference is difficult, however the following may be noted.

Plastic moulded models are popular, available in the larger cities, and usually remarkably accurate. They include a large variety of subjects, zoological, botanical, mechanical and so on. A very good series exists which deals with prehistoric animals. Another good series deals with all forms of road transport, yet another with shipping and aircraft. All of these, properly used, are of potential value in teaching.

A series of plastic moulded models of great interest to biology teachers relates to the human body and the sense organs. These can be purchased not only in finished form, but also as kits for assembly. Moreover, some of them are functional and not merely static models, dealing with both biological and mechanical functions.

A further opportunity exists in the appearance of new kinds of modelling materials, ranging from those which retain plasticity to those which set hard on exposure or by heating. Teachers should make a practice of watching shops dealing in such things and try to make educational use of all opportunities which arise.

Museum techniques have become very highly specialized, yet many of them are essentially visual methods of presentation. Their specialized nature is such that information concerning them must be sought elsewhere. One of the methods, the mounting of small biological specimens in transparent blocks is of interest. It not only preserves the specimen but also its colours. Such mounts have been adopted as ornaments. The resulting increase in sales has reduced prices so that they can now be purchased relatively cheaply at big stores and used for teaching.

Changes in regulations, or perhaps the lapse of patents, has led also to the appearance of a wider variety of mechanical constructional toys. The original meccano is brilliantly simple and provides in miniature everything from the real world of engineering—strip, girder, pulleys, shafts, gears and motors. Moreover, everything is interchangeable and multipurpose. Thus with a not very large basic set it is possible to illustrate and demonstrate a large number of important concepts and methods in certain fields of science and engineering.

Simple mechanical models are useful for many purposes in order to demonstrate the function of certain structures and processes—for example, the relation of valve and piston action in a steam engine or an internal combustion engine, or the movements of the jaw apparatus in a snake's skull. These structures are three dimensional but they can be reduced to a two-dimensional diagram. This is the method adopted in our textbooks and we make use of a series of pictures showing stage-by-stage movement. The pictures, however, are static while the process is dynamic. A greater degree of reality and a greater chance of understanding can be achieved with a working model. A model of a mechanical apparatus, such as cylinder and valves, made to scale, would be excellent—but it would be costly to buy and exacting to make. A two-dimensional model in plywood, a sort of working diagram, would be cheap, easy and quick to make and an effective mode of demonstration. This and the snake's jaw apparatus are but two examples of many models of this class—the 'working diagram'. Whatever the model the methods of making it are simple and, once the general idea is grasped, it can be adapted to special needs.

One important point should be noted here—which has been mentioned earlier (page 11). Models of this kind, because they are flat, can be made to fit the tray of the episcope. In this way they can be shown by projection on an enlarged scale. The work involved is little, if any, more—though greater accuracy and neatness are required.

We can take as our example the making of a working model of an internal combustion engine.

Materials

Plywood, about $\frac{1}{8}$th inch (3mm) thick (this can be cut from a tea chest); paint, screws, string.

Tools

Fret-saw and fine blades, cutting table, gimlet or drill, glass-paper.

Method: 1. PLANNING

(i) Describe the over-all size of the model.

(ii) Draw a full-size diagram with dimensions.

(iii) Determine which parts are to be fixed and which are to be movable and mark on the plan.

(iv) Decide how the parts are to be kept in place (in the model described here this was done by having the fixed parts overlapping the moving parts so that these could not fall out, or by having the latter held on a piece of wood sliding in a slot).

(v) Draw other parts which are required.

(vi) Trace out each part to *exact size* on a plywood sheet.

(vii) Cut the baseboard, etc.

2. MAKING

(i) Cut out each piece of the model with a fret-saw (cut close to, but outside, the line—the saw cut should almost touch the line).

(ii) Sandpaper the cut edges to a smooth finish on the line.

(iii) Cut the baseboard from thicker plywood (this can be made by gluing two thin sheets together).

(iv) Make the various other parts of the mechanism.

3. ASSEMBLY

(i) Glue fixed pieces to the baseboard—first the clearance or packing pieces, then the overlapping parts.

(ii) Place the moving parts in position and test them; use fine glass-paper on the edges until all parts slide smoothly.

(iii) Assemble all parts temporarily and test complete movement; adjust and sandpaper the edges as required.

(iv) Take to pieces, give one coat of thin glue size and a second coat of thicker size. Paint to required colours and varnish.

(v) Complete final assembly.

The important thing in making models of this kind is to have a clear idea of what is wanted and work it out on paper as a detailed drawing. Time and effort are often wasted by those who try to think out the model while they are building it—it can be done, but usually only by those with experience, and it often wastes material.

For some purposes thick cardboard is a good medium. It can be cut with a sharp knife along a steel rule with the card on a cutting board of wood or fibre, and can be glued together or stuck with adhesive tape. Thick cardboard bought new is very expensive. Old boxes can be used, but the board is usually softer and seldom available in large sizes—because of this it has been displaced by plywood to a large extent.

The advantages which are most marked in cardboard are the ease of cutting along a straight edge and the fact that it can be folded to give two surfaces at an angle to each other. This is done by cutting half through the card along the line of the angle and on its outer side, The increased ease of work, because of this, is seen in making a simplified model of a house. This can be cut from a single sheet of cardboard (as shown in Fig. 89) which is finally folded to shape. In plywood six pieces would have to be cut, two for back and front, two roof pieces and two end pieces; these would then have to be glued or nailed together with panel pins. The chief disadvantage is met with in cutting curves of small radius —this is easy with a fret-saw in plywood, but difficult with a knife in cardboard. It will cut with a very fine-toothed fret-saw if the cardboard is hard—but even then usually leaves a fluffy edge which is made worse by sandpaper.

The use of sheet metal raises various problems and

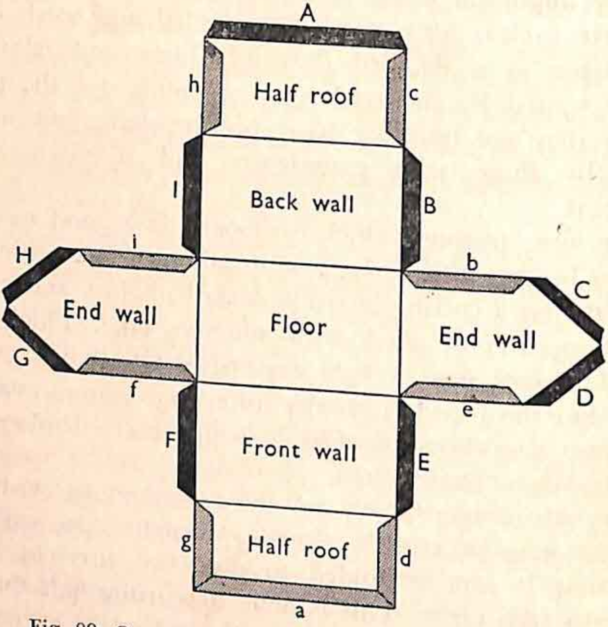


Fig. 89. One-piece plan for a cut-out model house.

calls for more elaborate apparatus and greater skill than cardboard or plywood. However, if one learns to use a few hand tools, such as tinman's shears and a soldering iron, it can be used for many purposes. Sheet tin is readily available from tobacco tins and the tins used for packing grocers' products. Metal-work is too specialized a craft to be entered into here but the beginner can learn by trying things for himself. The following points will help him in starting:

1. Work with sheet tin rather than brass or copper.
2. Use tinman's shears for cutting after scratching the design on the tin with a sharp point.
3. Small holes can be made in tin by driving a small nail through it and enlarging the hole with a tapered tool, such as the tang of a small file.
4. Whenever possible drill holes rather than punching them—but sandwich the sheet of tin between two thin pieces of wood and drill through these as well; if this is not done the tin will buckle or the drill snap off.
5. Soldering is quite easy, providing the surface is clean, a good flux (or resin-cored solder) is used and the soldering iron is hot.
6. When bending tin to a curve or a right angle always use a 'former' of hardwood and bend the tin round this.

It is sometimes necessary to cast metal to a particular shape, for example in making a counterbalance weight. If the resources of a workshop are not available this should only be attempted on a simple scale, using lead or solder. The process is similar to that of casting in plaster of Paris: make a mould and pour into it molten lead instead of plaster. Heat and melt the lead in an iron saucepan. Handle and pour it with extreme care.

Model-making in metal is a common hobby among the people of the West, nearly every district having its model engineers' society, and for juvenile interests there are all kinds of commercially produced construction sets —which are frequently used in university laboratories. These interests are only present on a very small scale in India and Ceylon, where the pattern of living is more rural and less industrialized. It is thus probable that this type of visual education will not be much used. Those who wish to explore it should realize that it can be done with simple materials and that the local metal-workers can be called on for help.

Before leaving model-making, which is far too big a subject to be fully treated here, we must make some reference to what are conveniently called 'functional' models. For many purposes we need something which demonstrates the principles of a process without necessarily also showing the structures concerned in representative terms—and here we use the functional model. Even though they may not have thought of them in these terms many teachers have used such methods. The chemist with models of atomic structure, the geographer with an orange on a knitting needle, the biologist with a balloon in a bottle—all are using functional models. In this way many subject teachers like to claim that they have been a long way ahead of the visual aids expert for a long time. With this claim we need not be concerned. The point for us to note is that models can be made by simple methods which add much to understanding. Our job, as teachers, is to explore these as fully as we can and to apply them as widely as we can; the fact that such methods have been rather narrowly restricted to the school laboratory does not mean that this is their only application, but that we have failed to recognize their possibilities.

The limits of space obviously prevent us from going into this matter in detail, but a few examples should suffice to open the way for individual development. Health education is a fundamental subject in the East and we find it being dealt with in many ways, through biology, hygiene, physiology and so on. Teachers frequently remark that they could 'make it more real' if they had more visual materials, particularly if they had a skeleton available for demonstration—to show points about bone movements, the mechanics of locomotion, points about posture and the like. An excellent way of dealing with this was worked out in Sweden by Dr J. Wintzell, who designed a simple wooden functional model of the human skeleton. At first sight (see Fig. 90) it looks very elementary and of questionable value; experience, however, has shown how useful it is. Dr Wintzell has designed many more such models. Every teacher should consider how far he can develop ideas of this kind for his own subject. Indeed such originality may not be necessary, because many of us do not make use even of simple ideas of this kind though they are described in most books. Steeped in a verbal tradition, we remain verbalists rather than visualists. The first, and perhaps the

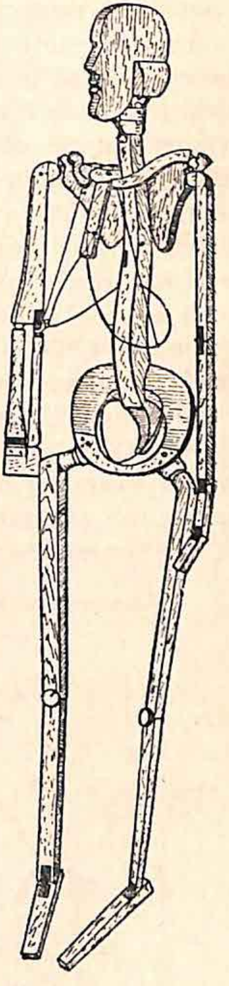


Fig. 90. Diagnostic model of a human skeleton (after Wintzell).

most important, step towards the visualization of education is to reorientate the attitudes of teachers—away from symbols to things and from details to principles.

An interesting form of visual presentation which has been explored in museum work but which could well be used in schools is known as the diorama. This is essentially a combination of a model with a painted background. When an attempt is made to give a model a realistic presentation this is usually done by setting the model on a baseboard and building up a setting for the model. Thus a history teacher sets his model temple in a sand tray and adds a model of the village, using sand, twigs and the like. From an oblique view this may be effective, but the background of school furniture and the like often spoils the illusion. The diorama is an attempt to overcome this by three devices : (i) viewing from eye-level, or just below it ; (ii) blending model into background ; (iii) setting the whole thing in a box to restrict the angle of view.

The important characteristic of the diorama is the

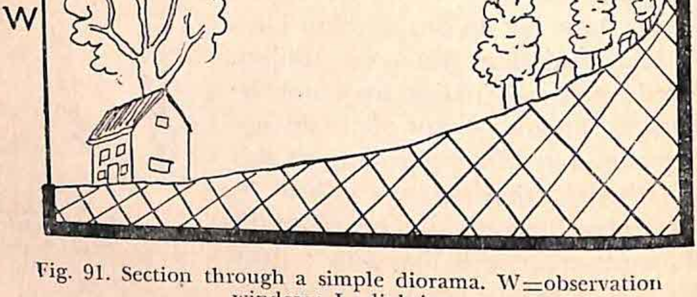


Fig. 91. Section through a simple diorama. W=observation window ; L=lighting.

blending of the three-dimensional foreground into the two-dimensional background, which achieves a degree of reality far superior to that obtained by merely having a flat vertical surface at the back. The whole illusion of reality depends upon this blending, which itself depends upon a careful use of exaggerated perspective. The construction of a diorama is shown in Fig. 91, which is a section from front to back of the box (shown by thick black boundary lines) in which the diorama is built. The floor rises from front to back and is built up on a supporting base and merged into the back wall. All the details from the foreground back into the distance are modelled in the solid and in perspective to heighten the illusion of reality—thus the houses and trees in the distance are smaller than those of the foreground. The details of the far distance are painted, to scale and in perspective, on the vertical back wall.

The preparation of a diorama undoubtedly takes a long time and some skill—and especially an understanding of perspective. The work and time involved should only be given to such a task if the teacher can assure himself that the result will make a real contribution to learning. For those who wish to undertake such a task the following hints may be useful:

1. Start with a simple diorama.
2. Draw a large sketch of the final result it is wished to achieve.
3. Draw a section, on the lines of Fig. 91, through the model.
4. Decide the relative sizes of the various parts and the degree to which they are to be solid, bas-relief and flat.
5. Build a suitable box with a removable top and a removable glass front.

6. Build up the concave backcloth and draw on it, in pencil, the pictorial elements.
7. Model on the backcloth the low-relief elements.
8. Make and set in place the foreground model.
9. Paint as required, using the inner surface of the sloping top and the top of the backcloth as sky.
10. Close the box and set on a viewing shelf.

The stages at which most difficulty is likely to arise are 6, 7 and 8. As work of this kind, when carried on in a school, will depend upon the use of materials, the minimum of apparatus and whatever skill and ingenuity the teacher can provide, it would be of little value to describe how these points are dealt with professionally. Instead it will be of value to describe how they can be dealt with under the limitations of normal school conditions.

The *concave backcloth* is most easily made by using a sheet of fairly stiff material which can be glued to the top edge of the back of the box and then draped down and forwards. Here it will need support. If the surface is to be regular and smooth it could be supported on, or even replaced by, a sheet of white cardboard. There are, however, advantages—such as a more realistic presentation of different planes and ease of attaching built-up details—in having the cloth thrown into folds, curves, hillocks and the like. This is done by building up a base from wood or with clay or stones; on this the backcloth is pressed into shape and glued into position. The whole surface should be given a coat of size and then a coat of flat white paint, or even a coat of a thin mixture of plaster of Paris. It is sometimes effective to curve the backcloth forward into the sky area.

The *low-relief details* lie in the intermediate zone between the two-dimensional backcloth and the markedly three-dimensional zone of the foreground. This low-relief detail should vary in its degree of relief: at the back it should be practically flat, a slight modelling on the surface, at the front (just behind the major model) the relief should be more marked. Probably the easiest way of handling this relief material is to model it in clay or papier mâché.

The *foreground model,* in three dimensions and with an exaggerated perspective, can be built from whatever material is thought to be best. A simple model, for example a house, can be modelled from clay or carved from fresh-set plaster of Paris. Alternatively it can be built up from wooden parts, cardboard, etc. The major difficulty here lies not so much in handling the material as in deciding the degree of perspective to be used. Here one must learn by experience, always working with sketches and looking at perspective drawings in magazines before putting one's ideas into solid form.

The illusion of reality and the degree of apparent stereoscopy will be heightened by careful use of colour and lighting. The colours used should be most clear, bright and varied in the foreground; as one recedes to the background they should become less bright, less varied and slowly approach the monochromatic hazy conditions we normally see in landscape views. Oil-paint can be used, but tempera, poster or powder paints will probably be most effective in unskilled hands. Lighting is important. A small diorama can be viewed in daylight, but internal electric illumination is undeniably preferable. If the latter is used it can be from a battery and low-voltage lamps, or from mains where they are available. In either case the lamps should be at the front of the model, high up and hidden from the viewer. If it can be fitted up, a horizontal tube light placed along the top front edge and hidden from the viewer is best of all. The switch should be conveniently placed outside the diorama.

As our experience of visual methods in education increases we are coming to realize that to use only the visual approach may be as profitless as to use only the verbal approach. Similarly we are realizing that the visual approach is a wide one and we may use it in many forms, descriptive, diagnostic, representative and so on. This realization has led to the use of multiple visual aids—we have learned to depend not only on moving film, filmstrip, chart or model, but on all of these. We have in fact developed what the Ministry of Education in England referred to as 'Visual Units'. This multiple approach is noted here because it suggests an avenue which any teacher can explore for himself—the use of several visual aids to deal with a single topic; nor should he forget that his teaching should range beyond these, as is suggested in Chapter III. Our purpose here is to explore not the theoretical but the practical aspects of this point: how, for example, can we best make use of a three-dimensional model and other explanatory visual materials? The answer to such a question must tend to be specific to the situation, yet it contains enough of generalization to be a guide in several situations.

Let us take, as an example, the question of understanding a contour map of a particular locality. We should already have provided some conception of what contours are; we are now turning to apply this in a specific situation. Doubtless we should first turn to the map of the region, choosing a suitable scale. This is a start with two-dimensional representation and we should try to have relief shown by hachuring, layer colours and contours. What else can we do to give added meaning? The obvious answers appear to be to use sections and a model. The sections we can draw in the normal manner from marked points on the map. The model we can build by suitable methods. We thus have three approaches to our problem—nor should we omit, if it is a local region, to go out and walk over the ground itself. If we are fortunate we may be able to use aerial photographs as well, both vertical and oblique.

The point to be made is simply that teaching and learning can be approached by multiple means and that, though it has been convenient to discuss two and three-dimensional materials separately, there is no reason for overlooking their relationships in actual teaching. We should aim at using visual aids not as a single method, but as a combination of methods. This will, of course, involve us in making more of such aids, which will be a good thing for our pupils; and we can seek help from them in the task.

In using the multiple or visual unit approach certain points should be noted. A visual unit or complex (the name is immaterial) should not always be looked on as complete—it should be capable of being added to—and this suggests that it should be planned from the start. Unless one has a clear plan it is easy to end in confusion. The plan should include the several elements which are considered necessary and also a carefully considered scheme of preparation. In the map example we used above it would be convenient to ensure that all maps and the air photographs are on the same scale, that the use of symbols is standardized, that the vertical scales of the sections and the models are the same as each other, and so on.

It is also essential to think about the method of presenting our materials—if they are just pinned up and laid about anyhow there is a danger that we shall end with confusion. To avoid this the teacher should turn back to the suggestion made in Chapter III concerning methods of using visual aids materials.

XII

HOME-MADE APPARATUS

ONE OF THE most astonishing things in England is the way in which teachers devote themselves to working for their pupils outside the classroom. We need not enter into the causes underlying this, beyond noting that teachers have a relatively high economic status (far higher than in India and Ceylon), that constructional hobbies and interests are very widespread and that most schools have some kind of technical resources. In these conditions an interest in visual education has developed very rapidly and the making of one's own visual apparatus and materials is common in English schools. To some extent this has been undertaken because the school cannot afford to buy commercially produced materials, and to some extent it has been undertaken because commercial products of the kinds wanted are not available. Much of the work so undertaken reaches a very high standard of production, but much of it is of the simplest kind ; all of it contributes to progress in visual education.

In India and Ceylon and other Eastern countries, where such conditions do not hold, it is important that something should be done to encourage initiative among teachers along similar lines. To do that is the major purpose of this book—to show that the visual approach to teaching is possible for them and that a start can be made without much in the way of technical or financial resources and almost without apparatus. There always comes a time, however, when some apparatus is wished for, even if it is not essential. It is to meet that moment that this brief chapter has been written. It aims at describing certain basic principles in designing and making apparatus and at giving some simple designs for building the kind of apparatus which lies within the compass of the normal teacher. There are many better designs and more workmanlike methods available—but they call for more in the way of technical skill and resources than is commonly found in the average secondary school in India or Ceylon. Simple as it is, that which is described here will work, and the interest and skill which come from making it may stimulate more advanced efforts, which can be guided by referring to the works mentioned in the bibliography.

The basic apparatuses which could be undertaken by any teacher with moderate skill and few resources are probably all included in the following list :

Opaque projection screen.
Translucent projection screen.
Tilting projection stand for strip projector.
Daylight projection set.
Simple miniature projector.
Simple episcope.

With such equipment a great deal of sound work can be done in visual education either by relying on commercially produced filmstrips or by making one's own as described in the following chapter. Designs and hints on making these articles follow later in this chapter and there is no reason why these should not be modified to suit local conditions or materials.

The teacher who wants to make his own apparatus should first get an understanding of certain basic principles which will guide him in designing and building apparatus

—though it is not essential to go into optical and other theory to do so. It is most convenient to deal with these point by point.

Projection Screens

The most commonly used screens are opaque and are viewed by an audience which has the projector behind it so that the audience is looking at an image reflected off the screen. Commercially produced screens are made of cloth with a surface of minute glass beads, or they may be painted with aluminium or white paint. While small ones may be rigid, large ones are either folding, rolling or collapsible.

The amateur, about to make his own screen, should take into account availability of material, portability and the quality of projection. The last-named is the most important, and the following points should be noted:

1. Bead or crystalline surfaces reflect light well but should be viewed from a narrow angle near the normal (see Fig. 93). Outside this the intensity and brilliance of the image falls rapidly.

2. Metallic surfaces, such as aluminium paint, give fair brilliance but this drops rapidly at wide angles of viewing.

3. Matt screens, such as white paint, give a lessened brilliance but may be viewed from a wider angle than other types.

TABLES

Picture size, throw and focal length

1. *Filmstrip*

(*a*) Double frame (36 × 24mm)

picture width	*focal lengths of lens (inches)*					
		2	3	4	6	
3′ 4″	—	4.5	7	9	14½	distance between screen and projector in feet
5′ 0″	—	8	12	16½	24½	
8′ 0″	—	11	16	21½	32½	

(*b*) Single frame (24 × 18mm)

3′ 4″	—	7	10	13½	20½	
5′ 0″	—	10	15	20	30	ditto
8′ 0″	—	16	24	32	48½	

2. 16*mm motion picture*

picture width	*focal length of lens (inches)*				
	1	1½	2	3	
3′ 4″	7½	12	18	24½	
5′ 0″	14½	22	29½	44	ditto
8′ 0″	19½	29½	39	59	

Relations between focal length, screen distance and picture width for 34 × 24 (double frame) transparencies

Picture width	*focal length in inches*					
	2	3	4	5	6	
40 inches (3′ 4″)	4½	7	9	11	14	distances from screen to projector in feet
60 inches (5′ 0″)	7	10	13½	17	20½	
96 inches (8′ 0″)	11	16	21½	27	32½	

It is suggested that for most school purposes a matt screen is preferable to any other and that it should be made by one of the following methods :

1. By painting a white rectangle or square on a convenient wall. The screen area should have a black matt border painted round it–about 4″ (10cm) wide.

2. By using a piece of heavy twill or canvas which can be dealt with in three ways : (*a*) Mounting it on a rigid wooden frame over which it should be tightly and evenly stretched–like canvas over a picture frame. (*b*) Making a wooden frame which can be taken to pieces for storage and to which the cloth can be tied when the frame is assembled. (*c*) Attaching the long edges of the rectangle of cloth to two wooden rollers so that the screen can be rolled up like a sun-blind. In each of these cases ensure that the cloth lies flat and free of wrinkles and finally give it a coat of flat white paint–a plaster of Paris or whiting finish cannot be used unless the screen

is rigidly stretched in a fixed position—it will crack and chip when folded or rolled.

3. By making a wooden frame with cross battens to prevent it from warping, facing it with a piece of plywood and then painting this with flat white and a matt black edge. Alternatively, the plywood can be covered with white blotting-paper glued into place.

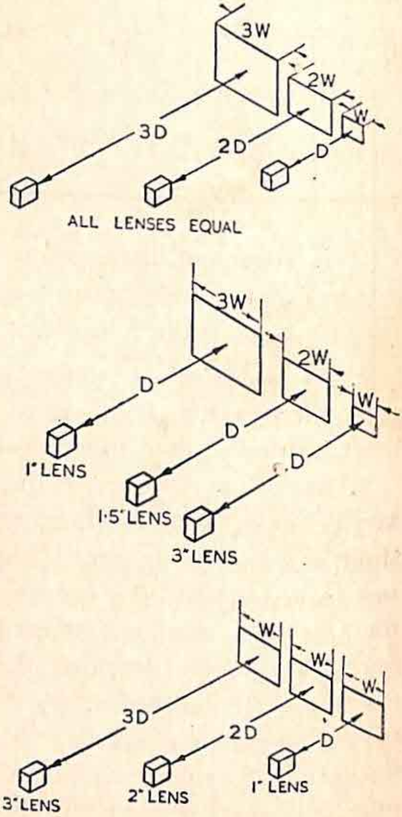


Fig. 92. Relations between focal length, length of throw and size of projected image.

The size of the screen must relate to the size of the picture. This should just fill the white area so that it is neatly edged by black. To achieve this requires some care in determining the size of the screen and the relative position of the screen and projector. In school projection one is usually working either in a classroom or a hall, requiring a small screen in the former and a large one in the latter. Two separate screens can be prepared, or the large one can be masked with black cloth when used for a small picture. The size of the picture depends upon the focal length of the lens and the length of the 'throw'—the distance between projector and screen. The relationship between these factors is shown in Fig. 92 for lenses of different focal length and can be found from the data in the tables. From these tables the screen width, W, can be found for different conditions.

Projection Conditions. In using a projector not only must the screen be of a suitable type but the projector and audience suitably placed. The best conditions for effective viewing are shown diagrammatically in Fig. 93.

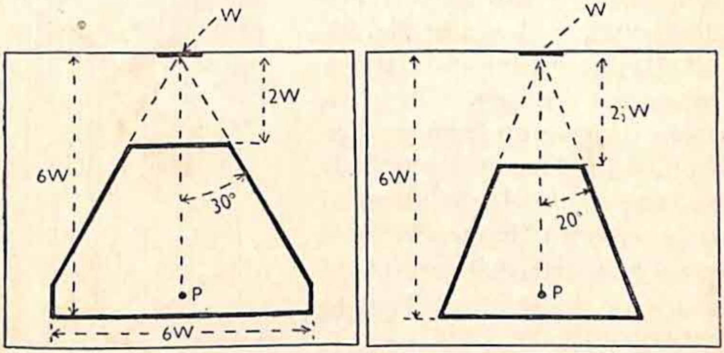


Fig. 93. Viewing conditions for different types of screen surface. On left: matt surface; on right: beaded surface. The area of effective viewing is bounded by a heavy black line.

W is the width of the screen. All the other distances should be related to this. Note that the audience should not extend back so far from the screen for still pictures as for moving pictures–simply because we expect them to see more detail in the former than in the latter.

Projection in Daylight. Schools in India and Ceylon often have half-walls, so that the classroom cannot be darkened during the day without a good deal of trouble and expense–hence one must be prepared to project in daylight. There are four ways of dealing with this :

1. High intensity can be adopted where mains current

is available. The disadvantages of this are that very many of our schools have no mains electricity supply and that considerable heat is generated; moreover, an amateur-built projector, as described later, is usually not suited to such high-powered illumination.

2. The screen can be placed between the open doors of a cupboard and further shaded from light by hanging pieces of black cloth, as shown in Fig. 94.

3. Use rear projection and a translucent screen. Such a screen is made up from tracing-linen, tracing-paper, lamp-shade parchment or plastic mounted on a wooden frame. With a frame as described above a slight protection from direct daylight is desirable. The lantern is placed *behind* the screen so that the audience is virtually looking into the beam of light reaching the screen. Because this is transmitted it will give a far more brilliant effect than would be seen with reflected light on an ordinary opaque screen.

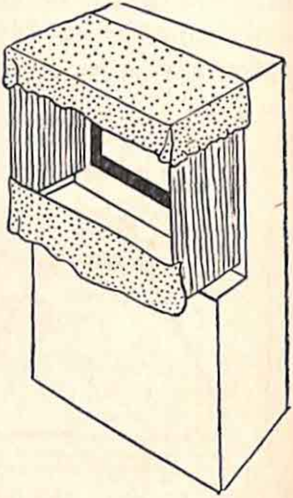


Fig. 94. Screen set up on a schoolroom cupboard and protected from extraneous light by the open doors and pieces of cloth.

A convenient design for a portable translucent screen for daylight projection is shown in Fig. 95. It consists essentially of a box, with open front and back and a screen sliding vertically on a frame into the body of the box. The openings at front and back are protected by three folding flaps. When closed (left) they provide protection for the screen against mechanical damage. When open

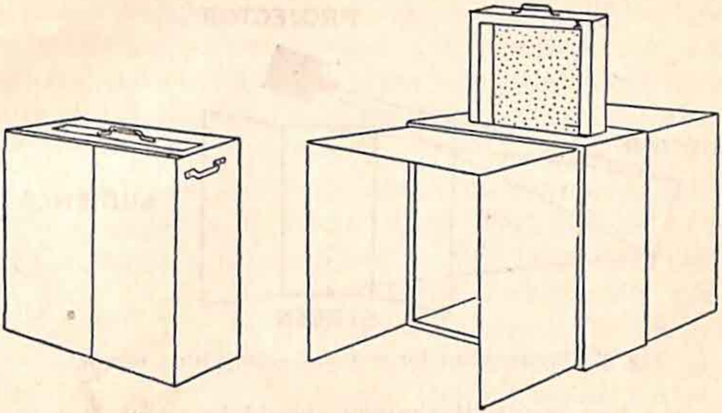


Fig. 95. A portable translucent screen.

(right) they protect the screen from stray light. The reason for arranging the screen on a sliding frame is to allow the screen material to be replaced easily if it gets damaged. The relative positions of projector, screen and audience for rear projection with a translucent screen are seen in Fig. 96. The film must be reversed in the projector to correct lateral inversion. Sound film cannot be reversed.

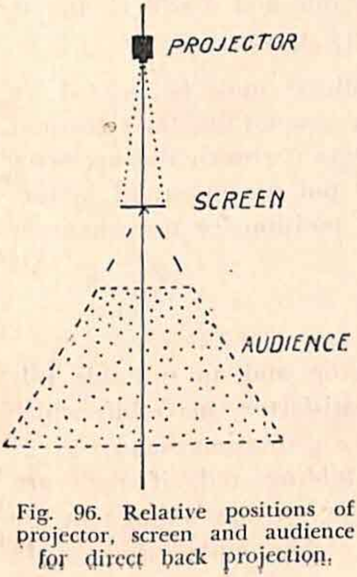


Fig. 96. Relative positions of projector, screen and audience for direct back projection.

4. Use rear projection with a mirror when the strip or slide includes print or figures —this corrects the lateral inversion noted above. The relative arrangement of projector, mirror, screen and audience is shown in Fig. 97.

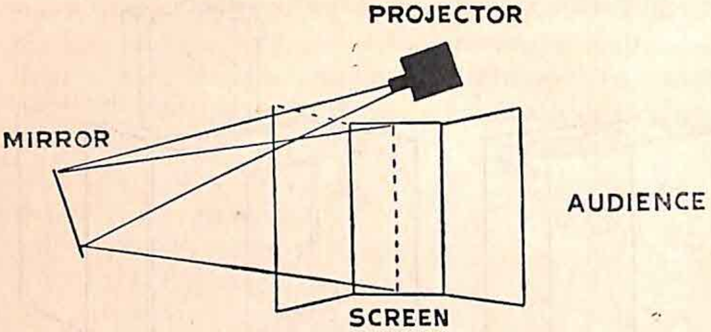


Fig. 97. Arrangement for rear projection with a mirror.

For the best results the mirror should be silvered on the outside. However, very thin mirror glass of normal type can be used, though there is a tendency for a double image to be formed, reflected from the outer glass surface as well as from the silver backing. This method is best used for projection on a small scale and it will be found that the angle of viewing is very narrow.

Choice between these possibilities must be guided by local conditions and needs. In general the first method is preferable. If one of the others is chosen the necessary apparatus should be simple to put up and rigid in use. If possible it should be left in position for use whenever required.

Projection Stands

Improvisation upon a table-top and an unstable pile of books is a common and unsatisfactory makeshift which should be avoided by making a projection stand.

Projection stands can be folding–and, if they are, they should be rigid when in use–or non-folding; in this case they must be easy to move about unless they can be fixed in a permanent position. The teacher should decide which will best suit his purpose and then use one of the designs given in this book, either to copy or as a basis to be modified. The following points should be taken into account :

1. If the projector has a camera bush in its base it can be mounted on a camera tripod, which will act as a stand. Camera bushes consist of a short brass tube with an internal thread and a rim-flange with screw holes for attachment. They can be bought cheaply from camera dealers. A rather expensive but very useful addition would be a tilting tripod-top, which is screwed between the tripod and the projector and allows the projector to be tilted.

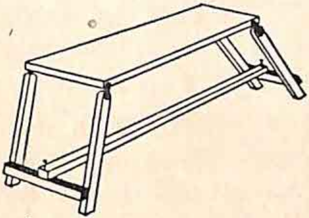


Fig. 98. A simple projector stand with hinged legs that fold inwards.

2. The folding projector stand shown in Fig. 98 is easy and cheap to make and folds almost flat.

3. Where daylight projection with a mirror is to be used the stand should accommodate projector, mirror and screen as shown in Fig. 99. The triangular base is made from three strips of plank. The projector at A rests on a platform made by leaving the side plank wide. The mirror is held in a block at B : the planks are screwed to this from below. C is a narrow strip screwed to the baseboard for the screen to rest on. Measurements and angles depend on focal length and screen width and are obtained by calculation or experiment.

4. Where illumination is not by mains current it is most convenient to make a projection table with a shelf or cupboard below it to accommodate the battery.

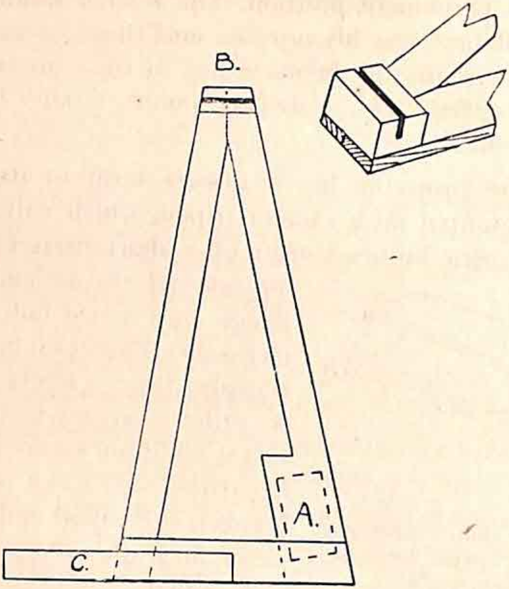


Fig 99. Plan of stand for rear projection with inset detail of slotted block to hold mirror. A: projector ; B : mirror ; C : screen.

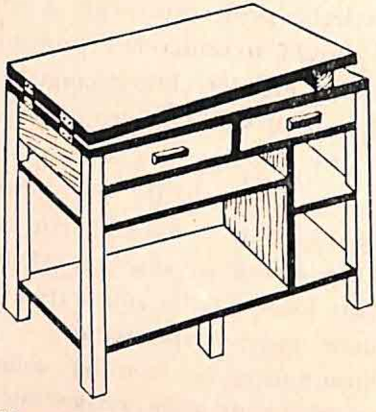


Fig. 100. A rigid projection table with shelves and drawers. The angle of the hinged top is adjusted by moving the wooden spacer.

The table should preferably run on castor wheels. It might be possible to use an existing small table as the basis and build it up as required. A design for a simple projection table is given in Fig. 100.

Illumination

In most towns in the West, and even in remote villages, a mains current supply is available, so the choice of an illuminant is simple—electricity is by far the most easy and effective to use. In India, however, and in Ceylon too, there are many schools without a mains supply; the choice must therefore lie between the following:

1. Home-produced current. Some of the large schools have their own production plants—their only problem is to be sure that the lamp is suited to the current so far as voltage and wattage are concerned. If they should be able to afford a moving-picture projector it will be necessary to ensure that this will work on direct current or alternating current or both, and match the projector to the current.

Portable generating sets can be purchased, but they are rather expensive.

Although it is not within the scope of this book to enter into details we can at least suggest the possibility of making one's own current with the aid of scrap materials and using wind (or water) as motive power. For example, a two-bladed propeller 4 feet (1m) in diameter could drive a 6- or 12-volt dynamo charging a car battery, which would supply current to the lamp. The propeller should be mounted on a ball-bearing axle from a bicycle wheel—indeed the wheel itself would make an excellent foundation for a windmill type of propeller. Bicycle gears and chain drive would step up the speed of rotation of the dynamo. The unit must be arranged to rotate on a *vertical* axle also, so that a tail vane can keep the propeller blades facing the wind. An automatic cut-out, also obtained from car scrap, should be put in the charging circuit. The whole unit should be accessible for maintenance but out of the way of the curious—e.g. on the school roof.

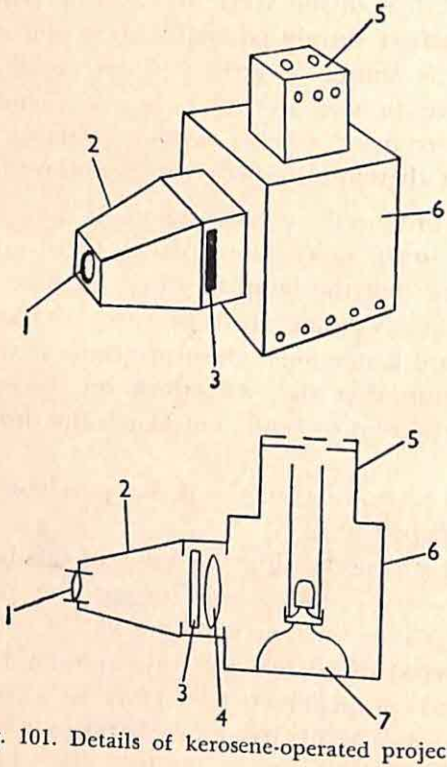


Fig. 101. Details of kerosene-operated projector.

2. A car battery can be used if one of the staff has a car which can do the charging; indeed one can plug straight into the car. Use can also be made of a local charging service.

3. A pressure kerosene lamp can be used, but it is more messy and more dangerous than electric current. Oil-operated projectors are on the market, and some ideas for converting a lamp are shown in Fig. 101. The upper figure shows the external housing built from sheet tin or based on a large metal box. The lower figure shows the apparatus in section. The various elements are numbered : lens (1), distance cone (2), slot for slide carrier (3), condenser (4), ventilator (5), body (6), and kerosene lamp (7).

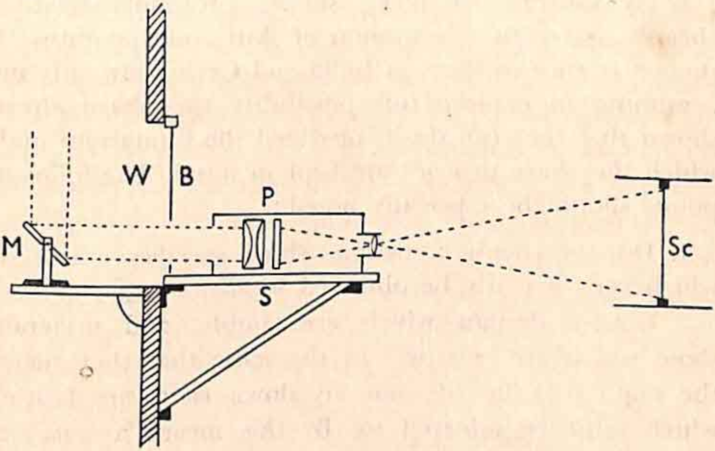


Fig. 102. Suggestions for sunlight illumination.

4. Sunlight, with a clear sky and the sun high overhead, is available throughout much of India and Ceylon for long periods. Amateur photographers use daylight for enlarging, and signalling by reflected sunlight is well known. It therefore seems possible that the heliograph might be adapted to illumination in a projector on the lines shown in Fig. 102. The apparatus is set up in a window space (W) masked by a black sheet of cloth or cardboard (B) with a suitable aperture. The mirror (M) is

outside in a gimbal mounting. The projector (P) has had the normal illuminant removed and is placed on a stand (S) to project on to a screen (Sc).

The chief mechanical problem to be met is that resulting from the apparent movement of the sun. A clockwork device could be used, but the hand-tilting mirror which is shown will be found fairly satisfactory.

Designing and Making Projectors

It is possible to make simple projectors relatively cheaply and with a minimum of skill and apparatus. Although science teachers in India and Ceylon are only now beginning to explore this possibility they have already shown that they can do it, provided the limitations under which they have to work are kept in mind. The following points should be especially noted :

1. Do not choose a design which specifies a material which cannot easily be obtained locally.
2. Choose designs which are simple, and preferably those which are 'elastic', in the sense that they suggest the main idea but do not lay down rigid specifications which must be adhered to. By this means a waste tin box can be used as the body of a projector instead of having to build it up to special dimensions from sheet metal.
3. Avoid complex processes, such as brazing, screw-cutting and the like, which call for skill and resources which may not be readily available.

The most satisfactory method for building one's own apparatus, since standard parts and accessories are not available, is to acquire one or two basic items and then build around them. Thus, while the teacher in England can readily buy, at a low price, a lens of a particular focal length, this is not so in India where stocks are not carried except by certain main agents. Thus it is necessary to overcome this difficulty, and a simple way is to buy a spectacle lens from a pavement dealer or junk merchant. The whole design is then centred round this spectacle lens, instead of buying a lens to suit the design. There are obvious limits to this, so one can only work within a certain range. For example, in a miniature projector the focal length of the lens should preferably be between 2 and 6 inches. It should be noted that certain dimensions will, in any case, be fixed—e.g. cinema film is 35mm wide, double-frame filmstrip pictures are 36 × 24mm, standard (British) slides are $3\frac{1}{4}''$ (82mm) sq. Thus other than variations dependent upon the diameters of condensers and lenses, the variables to be determined are distances between lens and slide, slide and condenser, condenser and lens, condenser and lamp, etc. Those who have even an elementary knowledge of optics can calculate these. As for others, the time-honoured method of trial and error has much to commend it—and its results will be equally good as guides for the constructor!

The carrying out of a trial set-up is easily performed by arranging the various elements—lens, slide, condenser and lamp—in such a way that they can be moved nearer together or further apart and the image thrown on to a screen. Each element can rest upon a block of wood, the blocks can be moved along a ruler, and the lamp can be screened by an upturned tin placed over it with an aperture to let light rays pass out. The limiting screen sizes should be from a small image a foot (30cm) across for individual examination up to one about 3 feet or one metre across for class-work. The relative distribution of the various elements required to achieve these sizes should be noted and made the basis of design.

The next step is to search for anything else which can be pressed into service, especially prefabricated units; tins, for instance, will make lamp houses and save a lot of time and effort in cutting these out from sheet metal. They can also be used, in many cases, as the main body of an episcope, though for this a large one is needed, such as a 14 lb (6.4 kg) biscuit box. As these are rarely available in the East a wooden box must often be substituted.

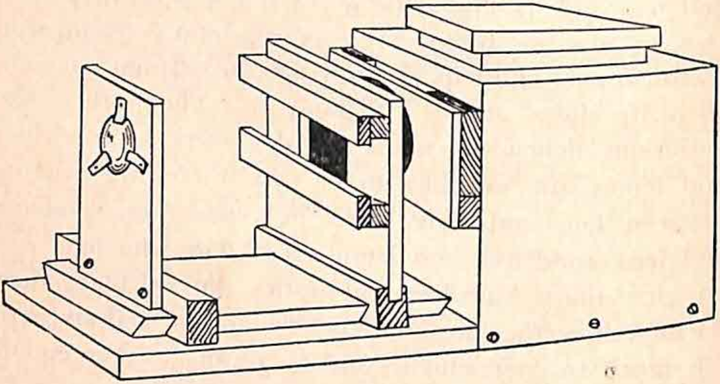


Fig. 103. External appearance of a home-made projector.

When neither a metal nor a wooden box is available a special one must be made. This can be cut and folded from sheet tin or sheet aluminium, leaving overlaps for the fastenings. The fastening can be with Meccano nuts and bolts or small soft rivets (aluminium). There is no need for a drill;

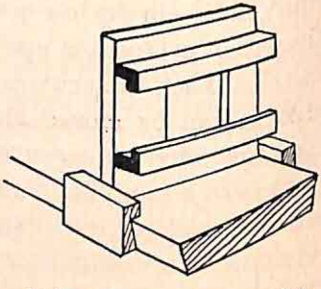


Fig. 104. A simple slide carrier.

the holes can be punched with a nail and expanded by forcing in the tang (handle) of a file or any other suitable spike.

In making a large body or lamp house it is desirable to build upon a framework for increased rigidity. This frame can be made of hardwood, and its joints must be very accurately cut to ensure firmness. The frame can be covered with sheet metal, or even with plywood.

For the baseboard, wood is most convenient as it is easily worked. The various parts of the apparatus are made to slide upon the baseboard, an action which must be smooth and neither too stiff nor too loose.

A Projector for Filmstrips or Miniature Slides

A diagram of a simple projector is shown in Fig. 103. The lens is bought from a spectacle maker and has a focal length of 10cm (4″). It is clipped on to the lens panel by three small bits of metal strip which are screwed into place. Both lens panel and slide carrier are arranged to slide by the method shown in Figs. 103 and 105. The slide carrier is in two parts, the sliding base and the panel which fits tightly into the slot on the base. This method allows the panel to be changed over for a horizontal or vertical picture in the case of a filmstrip, or to be exchanged for a carrier designed for slides. The method of making each will be seen from Figs. 104 and 105. Note the slope cut in the front of the sliding base to allow passage of the filmstrip when the carrier is arranged for vertical pictures.

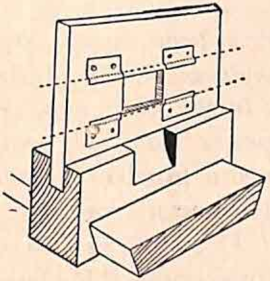
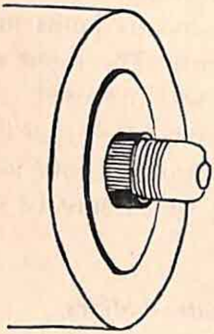


Fig. 105. Details of carrier for filmstrips.

The condenser slides into position between two wooden strips and is held in place by end pieces which are slid into position on each side of it.

The lamp house, as shown in Fig. 106 consists of a



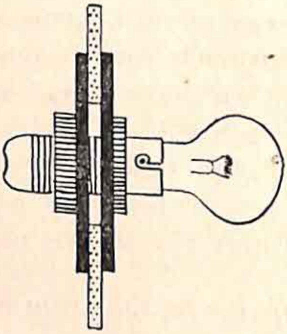


Fig. 106. Bayonet lamp holder in base of tin used as lamp house.
Fig. 107. Section through base of tin used as lamp house (stippled) with gripping discs (black).

tin container. The narrow sides have been cut so that the broad sides slip down at each side of the baseboard where they are screwed in position. In the bottom of the tin, which is now uppermost, a series of holes are made for ventilating purposes and a false top fitted over them to prevent light leakage. At the back one narrow side is cut away to give access to the lamp. This space is covered by a piece of black cloth during projection. The lamp, a car headlamp, is inside the lamp house. It must be on the optical axis and free to slide backwards and forwards. The simplest way of making it possible to centre the lamp is to fix the lamp holder into the base of a small tin, such as a circular 2 oz (56.7gm) pipe tobacco tin. In the bottom of this cut a hole about 1½″ (37mm) in diameter (this is much larger than the lamp holder). Now cut two tin discs, one as large as the base of the tin, the other smaller, but larger than the 1½″ (37mm) hole. In each cut a hole through which the lamp holder will just pass. Put the small disc inside the tin and the large one outside, one each side of the bottom of the tin. Take the lamp holder to pieces by unscrewing it, pass the body through the two tin discs and tin bottom, and then screw the collar on again. When this is tightened the holder is clamped to the tin ; thus the lamp can be moved up and down and right and left within the limits of the 1½″ circle. As the tin has been arranged so that its centre is already approximately on the optical axis, even the restricted movement allowed by this simple device is enough. The lamp can be focussed by the sliding movement already mentioned.

Simple as this machine is, it will give adequate illumination on a 30″ (75cm) wide screen in a dark room.

Another approach to the question of cost reduction, but intermediate between the entirely home-made (which may present difficulties) and the commercially produced (which is often too expensive for school funds), is the use of commercial units for the difficult parts of the job. The remainder can be home-made.

In the making of a small still projector for slides or strips the items which tend to present difficulty are (i) lamp-holder assembly, and (ii) focussing movement for the lens. Both items can usually be purchased ready for use either by buying a replacement item from the agent for a particular make or from a dealer in supplies for the home constructor. As such items may not be readily obtainable, except in the large cities in India, the addresses of a few outside sources have been given in the appendix. In making apparatus for still projection the author has dealt with Messrs Brunnings, who carry a large stock of useful and dependable items. Their lamp-holder unit (small centre contact) with mirror, which will take lamps from 100-500 watts is very useful. They also supply focussing movements, spherical reflectors, condensers, heat-absorbing filters and other parts for the making of projectors. Other firms, whose addresses are given in the appendix, also provide such materials.

A Simple Episcope

In attempting to make an episcope the first need is a good quality lens. To purchase a compound lens of suitable type, even second hand, may be excessively expensive. Though old camera lenses can be bought they are rarely suitable as their effective aperture is too small. A compromise is to get as good a reading glass (magnifying glass) as one can and use this as a lens.

Trial and error must be used to determine the distance between lens and picture at different 'throws', that is with the image at different distances and of varying sizes. Having decided what amount of movement is required to focus at different distances, next determine the distance between lens and picture for a medium-sized image.

The lamp house or body must be based on this distance. That is, the body must be of such width that this is the right distance between the picture and the lens for a medium-sized picture; and the lens must be free to move nearer to the picture and also further away from it, thus giving images of different size.

The lens should be mounted in a tube, such as a cylindrical tin. This is done by cutting two wooden circles which will slide into the tin. Next cut out the centres of these discs to form two wooden rings. Slide one into the tin and fix it with screws put through the tin into the wood. Next slide in the lens and then the other wooden ring, which must be right up against the lens when it also is screwed in. The lens is now held in the tube.

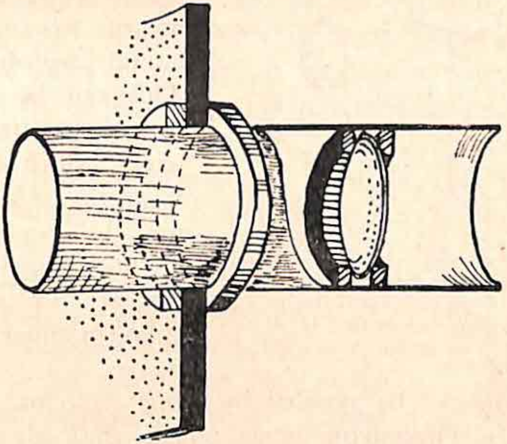


Fig. 108. Lens mounted in lens barrel which slides into front of episcope body. Shown partly in section.

To allow for the focussing of the lens a circular hole is now put in the lamp house body in which the lens tube will slide. To give a greater supporting area make a pair of wooden rings through which the lens tube will slide and screw one each side of the lens tube aperture in the lamp house body. The result of these procedures is shown in Figs. 108 and 109.

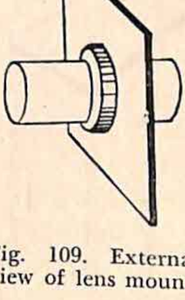


Fig. 109. External view of lens mount.

The episcope requires not only a dark room, but strong illumination, such as four 100-watt lamps. These are placed on the same wall of the lamp house as the lens, which is shielded by its tube from the light, except that reflected from the picture,

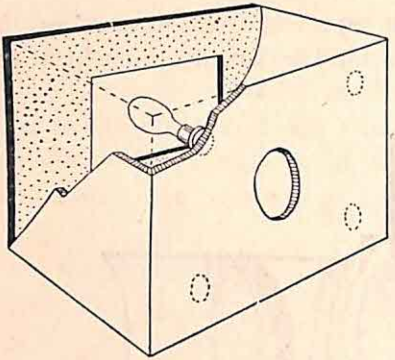


Fig. 110. External view of episcope body, partly cut away to show one lamp and the picture aperture in back wall. The lens aperture is shown in front.

In a simple model of the kind described above and shown in Fig. 110 there is no mirror to correct the lateral inversion effect. This can be overcome by using a translucent screen which is viewed from the side opposite to the episcope, a method which has the further advantage of giving a much brighter image.

Inversion can be avoided by using a mirror, as shown in Fig. 111. The mirror can be outside the body, reflecting rays which have passed through the lens, or inside the body between picture and lens, as it were. These two

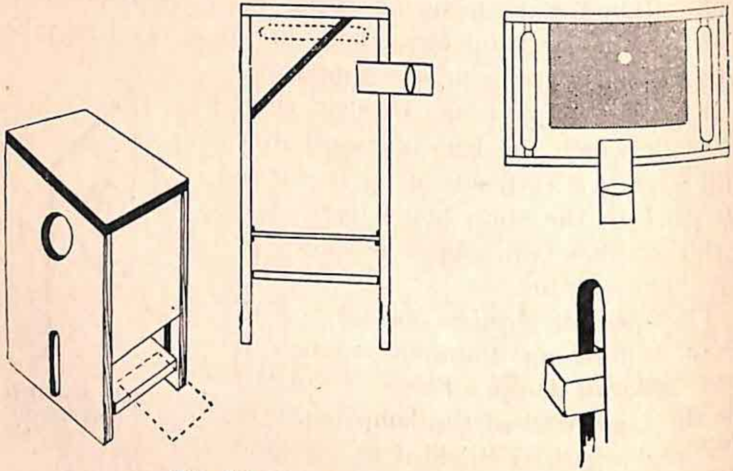


Fig. 111. Details of a mirror-episcope.

positions are shown in Fig. 2. A mirror-episcope can be made, using the principles already described and arranging the various parts as shown in Fig. 111. It will be noted that in this design the picture is placed on a horizontal tray which slides in three grooves through the aid of three small lugs or tongues. These should be a smooth fit, so that the tray moves easily. It will stay in position by a very slight degree of tilt which puts the projecting tongues out of alignment and causes increased friction. If a book or other object is placed on the tray this method of support may not be sufficient and a couple of coil springs can be put at each side, between body and tray, so that they tend always to pull it upwards (see Fig. 112).

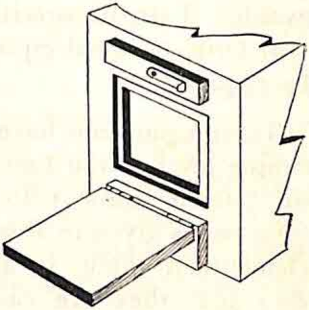


Fig. 112. Details of a picture-holding device for an episcope.

The picture or book must be held in position in one plane with the aid of a sheet of glass in the bottom of the body.

The mirror used in an episcope, and for back projection, should be silvered on its surface to avoid a double image, one from the glass surface and one from the silver at the back of the ordinary mirror. However, surface-silvered mirrors are not readily obtainable and may be expensive, and an ordinary one can be used providing it is very thin.

If teachers in the East are to make their own apparatus it must be of simple design, making the least possible demands in construction. The following points should be noted :

1. Wherever possible, easily obtained materials must be used.
2. The design should not be complex and rigid but allow of easy modification so that, for example, an already existing tin box can be used instead of having to build one to special limits.
3. The processes involved must be simple. Brazing, thread-cutting, curves or circular apertures should be avoided. Extreme precision should not be necessary.
4. Only minimal equipment in the way of tools should be required.

These conditions have to be intepreted on a much more simple level in the East (on the whole) than in the West, so that, to those with greater skill and resources, the suggestions given in this book will appear to be extremely elementary. That is an essential condition. Simple as they are, they are easy to make and they will work effectively. After making them the experience gained will be a sound basis for attempting something more elaborate.

XIII

MAKING FILMSTRIPS AND FILMS

WHILE WE ARE most concerned with using visual aids it is not out of place to discuss making them; but, because the technical processes are complex and this a general book, our treatment of the subject-matter of this chapter must be brief. It possesses two aspects, the photographic and the educational, and it is on the happy union of these two that the production of good filmstrips and films depends. In England many excellent films and filmstrips have been made by school-teachers and, despite various handicaps, there is no reason why the same should not be done in India and Ceylon. In any case there will be an increasing call, in these countries, for help from teachers in guiding commercial and official production of educational films. If this guidance is to be adequate the teachers concerned must have some knowledge of production. This chapter is therefore devoted to an extremely simple description of how to make filmstrips and films by photographic methods—something has already been said about non-photographic methods.

First it is necessary to understand, in outline, the photographic process. Basically, and in much over-simplified terms, this depends upon the fact that if certain salts of silver are exposed to light and then treated with certain chemicals they are reduced to metallic silver. By having the sensitive silver salts on a plane surface (in film or on a plate) and allowing an image to be formed on this with a lens we can finally get an image in silver grains on our plate. In order to prevent unwanted light from affecting the film we enclose it in a box (the camera) with the lens mounted on its front. In order to control the amount of light reaching the film we use a shutter. And, for various reasons, we treat the film in particular ways. We might tabulate and further explain the process in the following way :

THE PHOTOGRAPHIC PROCESS

Stage	*Apparatus*	*Method*	*Purpose*
1. Exposure.	Camera and film.	With shutter.	To form latent image in the sensitive silver salts by action of light.
2. Development.	Dish or tank in the dark.	Chemical action of developer brings about reduction to silver of those salts which have been exposed to light.	To change latent image to a silver image which is a *negative* ; e.g. white clothes appear black.
3. Fixation.	Dish or tank in the dark.	Dissolving action of hypo (sodium thiosulphite).	To remove all silver salts which have not been reduced.
4. Washing.	Dish in sink in light if convenient.	Washing in running water or several changes of still water.	To remove all traces of hypo.
5. Drying.	Clips.	Hang up in dust-free air.	To harden film by removing water.
6. Printing.	Printing frame or box.	Exposure to light, development, fixation and washing.	To produce final positive print on paper.

With this brief guide to the process we now must note how it is adapted to the making of filmstrips.

The *camera* must either be made to use 35mm film or adapted to do so. A simple box camera of V.P.K. size could be used, but a more elaborate folding camera is preferable.

The *film* used should be a fine-grained panchromatic type. These are available for 35mm cameras in lengths of 5¼ feet (157.5cm) giving 36 exposures, each 36 ×24mm —known as 'double frame' size.

The *developer* should be of fine-grain type. A suitable formula is Kodak DK 25, made up as follows:

Metol	7.5 grammes
Sodium sulphite (anhydrous) ...	100.0 „
Sodium bisulphite	15.0 „
Water	1000 c.c.

A special developing tank is needed, but short lengths can be developed in a jam jar.

If no dark room is available, work at night with curtains drawn so that *no* light can enter the room. If this has to be done, desensitize the film after removal from the camera by placing it for two minutes in the following solution: Pinacriptol green—one part in 20,000 of water.

A portable dark box can be made from wood with holes for the hands through which light cannot enter because each hole is protected by a sleeve or tube of cloth through which the arm passes. All operations are carried out in the box. Details of this method and of all other aspects of filmstrip making are adequately described in reference books of which some are written specially for teachers. Use an acid hardening fixing solution made as follows:

Hypo	300 grammes
Potassium metabisulphite ...	25 „
Chrome alum	12.5 „
Water	1000 c.c.

Leave the film in the hypo until all creamy colour has gone, and then give another five minutes.

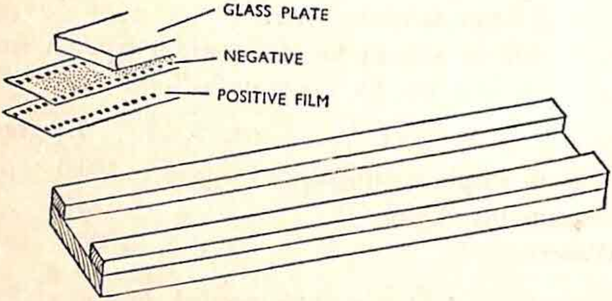


Fig. 113. A simple printing frame for 35mm film.

The *printing process* is modified because we need not an opaque print but a 'transparency' which can be used in the lantern. Instead of using printing paper we use slow positive film such as Kodak Microfile or Ilford Microneg. The makers give instructions as to development.

The time of exposure must be found by experiment, but with a normal negative 6 feet (1.83m) away from a 60-watt bulb it will be about half a second.

The transparency is made by putting a piece of unexposed positive film under the negative, with the two emulsion surfaces in contact. Single exposures are made by cutting off a short length of film and using a small printing frame. A strip is printed with a long narrow frame, as shown in Fig. 113, which will accommodate twelve pictures. The frame consists of a base plate 20″ (50cm) long to which two narrow strips are glued, leaving the space between them wide enough to accommodate the 35mm film (i.e. just over 35mm wide). The positive film is placed in this trough, emulsion side up; next the negative is introduced with the emulsion downwards, and finally the glass cover plate. To ensure complete contact between the film surfaces elastic bands or clips are used at each end of the frame, with the precaution that they do not interfere with the two end pictures. For longer strips a mechanical printing box is desirable, and a suitable pattern can be found in books mentioned in the bibliography.

The *positive transparency* can be used in strip form or mounted as miniature slides. There is no need to use glass for this as it adds to the cost, though it does protect the film. In the tropics it is inadvisable to use glass because fungus spores easily infect the film and the fungus cannot be removed without taking the slide to pieces. Instead use one of the following three methods :

1. Hinge together with flexible binding tape two pieces of glass each 50mm square. Mask one with black paper to leave a central aperture 36 × 24mm. Use this as a temporary holder for single transparencies.
2. Cardboard, which will not require masking, can be used. Cut two squares with 50mm sides, and cut a central aperture 36 × 24mm in each. Place the film between them and bind the edges.
3. Cut 50mm squares of cardboard each with a central aperture 36 × 24mm. Make a permanent mount of each single exposure in the following way :

(i) Lay one cardboard square flat on a table.

(ii) Paint its upper surface with a thin layer of a quick-drying cellulose glue which can be bought in tubes.

(iii) Lay the transparency in position centrally over the aperture.

(iv) Paint another cardboard square with cellulose glue and lay in register on the top.

(v) Leave under slight pressure until dry.

(vi) Paint a layer of thicker glue round the edges of the slide.

(vii) Print the title of the picture on one side of the slide and add two black spots on this side near the top edge with the picture upright.

The picture has now been 'sandwiched' between two pieces of cardboard and makes a permanent slide which can be handled by the edges to avoid leaving finger marks on the film surfaces. The chief advantages of this method are ease and cheapness of the process, protection, and the possibility of sorting the slides into any required order.

If pictures are arranged in sets of six all relating to one topic and if these have been printed in the correct order on a length of film, this can be mounted, as above, but using larger cardboard frames.

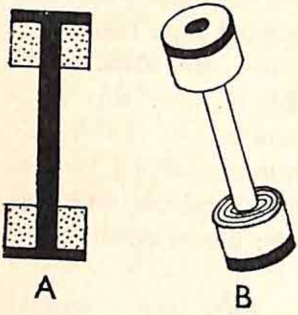


Fig. 114. Adapting a larger spool for 35mm film.

All slides should be stored in boxes to protect them from dirt and damage. The most convenient storage box has racks down the sides (see Fig. 23) into which the slides are inserted in a vertical position.

The Camera

We must consider in greater detail the camera and the various points which are important if it is to be used successfully for 35mm work.

Adaptation to use 35mm film. Some cameras are built to use 35mm perforated film, others use film of this width which is not perforated, while the most commonly used cameras use film of greater width, usually $1\frac{7}{8}$ or $2\frac{1}{2}$ inches (60mm). The first two types require no adaptation. The third type can be adapted by various means which have been described in many books. The beginner is advised to use the simplest method, which is probably as described below.

1. Obtain two empty film spools. Measure the width between the ends or note the width of the film in millimetres. From this subtract 35mm to get a difference which must be divided by two. This last value shows what has to be added to each end of the spool in order to build it up to accommodate neatly the 35mm we wish to use. Let this width be *x* mm on each side.

Cut two long strips of paper *x* mm wide. Using a hard-drying glue, build up the ends of the spools by rolling the paper round the core in a spiral so that a thick disc is built up at each end. When dry we now have two spools which will fit the camera but will take 35mm film. (See Fig. 114)

2. The next problem is picture size. Open the back of the camera and from hard, thin cardboard cut a mask which fits it exactly; then, in the centre of this mask, cut an aperture 36 × 24mm. Paint both sides of the mask with indian ink or black paint and fix the mask in position by any convenient method. The camera will now hold film of a new width and take pictures of the required size.

Figure 115 illustrates this. A is the mask (cross-hatched, with a heavy line round the edges). B is the outline of the 35mm film centred by the adapted spools (not shown). C is the new picture aperture 36 × 24mm. D is the original picture aperture, shown by a dotted line.

3. Take a complete length of the red (or green) backing

paper which is wound on the original spools and cut it down its length, making it 35mm wide. This must be exact and neat.

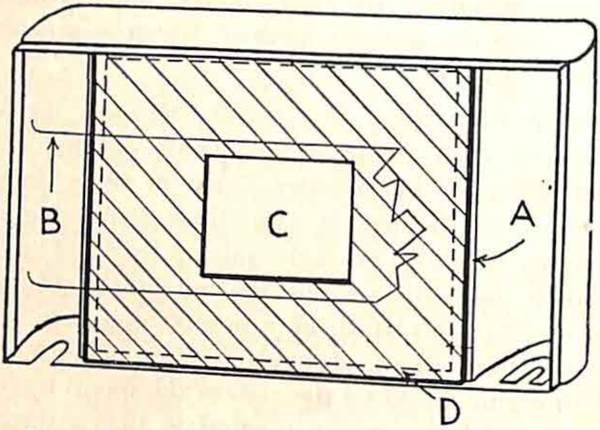


Fig. 115. Adapting a camera back for 35mm film.

4. Wind 2 or 3 inches (50 or 75mm) of this strip on to a spool and mark the paper where it winds on to the spool. Then lay it out flat on a table with the black surface downwards. On the upper red side are the numbers used in winding on the film from picture to picture on the original size. As we have altered the picture size we must also alter the numbering. This is done as follows: from the line drawn on the paper measure back an inch and draw a line across the paper. From there measure back 40mm and draw another line and proceed in the same manner until within 4 inches (10cm) of the end of the paper, which is now divided into a series of rectangles. Draw diagonals to find the centre of each and then number in sequence from 1 onwards (see Fig. 116).

N.B. This method assumes that the red window is in the middle of the camera back. If it is not, the position of the new serial numbers must be so altered that they are visible in the window. Wherever the numbers are, each should be preceded by a row of warning dots.

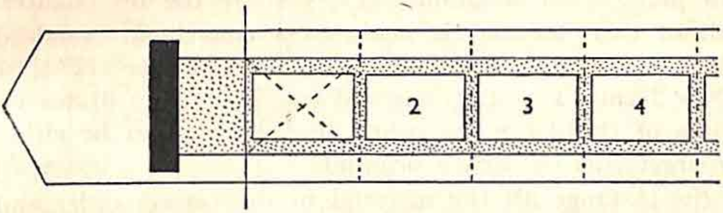


Fig. 116. Renumbering backing paper for 35mm film.

Loading the spool must be done in the dark. Pin out the paper backing, black side upon the bench, and mark the position of frame 1 or its limit by a pin in the desk so that it can be located in the dark. Have pieces of surgical adhesive tape 1″ (25mm) long ready at hand, one near the pin and the other at the far end of the paper. Switch off the light, open a tin of unexposed film and, with the adhesive tape, attach it, emulsion upwards, to the roll of backing paper. Roll out the film towards the other end of the paper, cut it off about 4″ (10cm) from the end of the backing paper and attach with the other adhesive strip. Now roll the backing paper and film up on to the spool so that exposure No. 1 comes on the outer end. The roll can be inserted in the camera at once or stuck with adhesive tape until required.

Making the Filmstrip

A filmstrip will usually contain some pictorial matter, some diagrams and some printed matter. Into the questions of selection and arrangement of the matter we shall go later; here we are concerned with the more technical aspects of production. The general method used in professional work is to: (i) assemble the pictorial matter; (ii) prepare the diagrams; (iii) prepare the text matter. All of this material is made to a convenient standard size, which for 36 × 24mm frames could be 12″ × 8″ (30 × 20cm). The diagrams and text matter are drawn on cards of the size given, while the pictures can be either enlargements or artist's originals.

(iv) Arrange all the material in the correct order and label each from 1 to the end of the series, with ·1 on top. (v) Now photograph them, one after another in order. (vi) Develop, fix and wash to produce a master negative. (vii) Print positive copies from this master strip as required.

The task of the amateur is to adapt this process to his purpose in a way which demands the minimum of expense, time, skill and materials. There are many ways of doing this and experience suggests that the following points should be noted:

1. The amount of photography should be minimized.

2. Amateur strips should be either all pictorial or all diagram, plus text if possible, rather than a mixture of both.

3. If the strip is all pictorial it can be made by contact printing direct, and in appropriate order, from the original negatives if these are in 35mm film.

4. If the strip is all diagram and text, it can be made by a single photographic process by drawing the diagrams and printing the text with a bold white chalk line on a good blackboard evenly lighted. Each frame can be done and photographed and rubbed off in order to draw and photograph the second one, and so on. When projected, the diagrams will show as black lines on a white background.

5. Where pictorials, diagrams and text have to be mixed in a film one can copy the professional and prepare them as enlargements, drawings and printed texts, all to a standard size of 12″ × 8″ (30 × 20cm). This involves a maximum amount of photography.

Close-ups

To photograph something only 12″ × 8″ with an ordinary folding camera presents a problem, as such cameras usually do not focus objects nearer than 3 feet (1m)—at which distance the image is rather small. It can be enlarged on the film by using a supplementary or ' close-up ' lens. For some cameras ' portrait ' attachments can be bought. For others one need merely put a spectacle lens in front of the camera lens and observe the following five points :

1. Choose a spectacle lens of suitable focal length—about 30cm is suggested as a trial.

2. Place this in front of the camera lens and hold it in place with three small dabs of plasticine or a bit of adhesive tape.

3. Set the camera focussing at the ' infinity ' mark on the scale.

4. Place the object to be photographed in front of the lens at a distance equal to the focal length of the spectacle lens—in the case suggested this was 30cm.

5. Check the accuracy of the focussing as follows :

(i) Open the back of the camera (no film should be in it for this trial).

(ii) Place a piece of tracing-paper flat against the picture aperture cut in the mask.

(iii) Shade the tracing-paper, which acts as a focussing screen, from side light.

(iv) Check the focus of the image on this focussing screen.

(v) Should the image not be in sharp focus, move the object (enlargement or the line drawing, etc.) nearer to or further from the camera until sharp focus is obtained.

(vi) Measure the distance from object to lens and make a note of it. In future work set up the camera with the supplementary lens and the object at the distance found by the above check. The picture will then always be in focus.

Note also these three important points in copying:

1. Even lighting of the object is essential.
2. The iris diaphragm should be closed down to decrease the aperture through which light passes, thus increasing the depth of focus.
3. The correct exposure must be found by a few experiments.

The preceding notes on the photographic side of film-strip making are exceedingly brief and they describe only the most elementary points and methods. However, they are enough to act as a guide to getting results, and a little experience will soon overcome any problems which arise. Before leaving this aspect one more technical method may be described.

When the film which has been exposed in the camera is developed the result is a negative. The production of the positive transparency requires the further photographic process of printing. The question arises as to whether the film could not be directly developed as a positive, thus cutting a whole laborious stage. This possibility, known as direct reversal, is the basis of amateur cine-film making. Although there are few films available specially made for this process, it can be done with many films which are normally used to produce negatives.

For the amateur it is preferable to use a reversible film, such as Gevaert 'Dia-Direct' 36mm film. The makers give full instructions for its use. This film has to be processed by the makers or their agents.

Those who wish to do their own processing can make use of other materials and methods. One example of each is given.

1. *Using direct reversal film.* Kodak produces Kodak Direct Positive Panchromatic Film. This is fast, fine-grain panchromatic film with an antihalation backing. By reversal processing a positive is made direct from the film exposed in the camera. This film, however, can only be bought in rolls of 100 feet (30m) of 35mm. It can be processed by the user with the special chemicals produced by Kodak as the Direct Positive Film Developing Outfit.

2. *Chemical reversal of a negative film.* It is known that several films normally developed to the negative form can be reversed while processing, so that a positive is produced. Kodak Panatomic X 35mm film can be so reversed, offering the great convenience of 36 exposure packing, in contrast to the 100 feet (30m) lengths of Kodak Direct Positive.

Reversal of Kodak Panatomic X can be achieved by using the Direct Positive Film Developing Outfit referred to above and by rating the film, for reversal processing, at a Kodak Exposure Index of 80 for daylight or 64 for tungsten.

Ilford Pan F film can be reversed by the user as shown in the *Ilford Technical Information Sheet No. T.* 203.

In all the cases mentioned the procedures are simple and both Kodak and Ilford will supply full instructions upon procedures.

Those who wish to take this matter further should investigate the Arneleon Reversal System which is described in some detail in the *British Journal Photographic Almanac,* 1961, p. 259.

Sub-Miniature Methods

Sub-miniature cameras, which are presently defined as cameras using film of less than 35mm width, also have a claim to our attention.

The earliest of the precision sub-miniatures, and still the smallest 'real' camera, was the Minox. This appeared on the market in 1937 and immediately became popular. It used specially packed 9.5mm unperforated film giving 50 exposures with frames 11 × 8mm. The modern Minox B with built-in semi-coupled electric exposure meter, built-in filters and a number of accessories, is widely used by professionals who need a small unobtrusive camera for recording and note-making which can be focussed direct to 8″ (20cm).

Among the accessories available the following may be specially noted:

1. *Angle viewer,* enabling photographs to be made at right angles to apparent direction of attention. This is excellent in making records of behaviour.
2. *Reflex mirror viewer,* allowing use of the camera at waist level, useful in photographing plants.
3. *Binocular attachment,* permitting use of the camera attached to binoculars which operate as a long-focus telephoto lens. Very useful for distant scenery, high-up architectural details, shy fauna or inaccessible flora.
4. *Copying devices,* one portable and one for use with the Minox enlarger. Both make the act of copying simple, quick and efficient.

5. *Precision enlarger.*
6. *Precision projector* for transparencies mounted in 3 × 3cm card mounts.

Sub-miniature photography has in recent years become highly developed, with a number of different makes of camera available. The great advances in lens performance, film quality and camera construction make it clear that small format work can be of high level. Nearly all sub-miniatures other than the Minox use 16mm film, though the negative sizes may vary from 18 × 12mm to 10 × 10mm with 14 × 10mm as the most common size.

The convenience of these small cameras, the high level of the work which can be done with them, their relatively low cost (though some are very expensive), and the cheapness of film, especially when bought in bulk, give them a great appeal to the educationist.

Some indications of what is available may be offered in brief notes, dealing with a small selection only.

Very expensive high precision types:

Ga Mi 16, made in Italy, the most costly of all.

Minox (9.5mm film) referred to earlier.

Minicord, twin lens reflex giving negatives 10 × 10mm on 16mm film.

Medium class cameras with special features:

Goldeck 16 (14 × 10mm frame), interchangeable lenses.

Mec 16 (14 × 10mm), two models, one with fully coupled automatic exposure meter.

Mikroma (14 × 10mm) with special stands for copying work.

Low-priced models capable of very good work:

Minolta 16 (14 × 10mm frame), simple, but with a range of accessories. Available in simple form and also with fully coupled exposure meter making the camera automatic.

Mamiya 16 (14 × 10mm frame). Available in two forms, one simple, one with semi-coupled meter.

Specialized models :

Mikroma Stereo, uses 16mm film to produce stereo-pairs, likely to be useful where spatial perception is important, as in morphology and physical geography.

Viscawide, uses 16mm film with a wide-angle swinging lens to provide panoramic views. Likely to be useful in geography teaching.

Compendica, uses 16mm film in spools of 25 or 100 feet (7 or 30m) and has built-in meter and provision for synchronized recording on tape. This, though expensive, may be of interest for school expeditions.

Even these brief notes indicate that there already exists a considerable variety of sub-miniature cameras for which accessories of all kinds, including enlargers and projectors, are available. The reductions in size and cost and the high level of efficiency now achieved suggest that the sub-miniature field will be exploited in the interests of education. In particular the very greatly decreased costs of raw materials will make it possible for much more practical photography to be carried out in school by staff and pupils.

Any teacher contemplating the use of photography for educational purposes for the first time would be well advised to explore the sub-miniature field in detail. All the principles and procedures referred to in connexion with 35mm work apply in the sub-miniature world of still photography on 16mm film, at reduced cost. Explorations of the possibilities of the new formats, now being made by the writer, indicate their many conveniences and advantages. It is hoped, in due course, to be able to prepare a small guide specifically devoted to this kind of educational photography.

The Educational Side

We now turn to the educational side of making a filmstrip. First we must be clear about what we want it for. The simplest answer to that is that we need pictures and diagrams for the following purposes :

1. To give a visual sense of reality to what we talk and read about, which is otherwise completely verbal (because our books have so few pictures).
2. To give concrete form to abstract ideas.
3. To give background material which will add meaning or give a direction or orientation to pupils' thinking.
4. To analyse complex situations into their simpler components.
5. To synthesize situations, facts and ideas into new relationships.
6. To give stage-by-stage demonstrations of processes.
7. To provide a quick epitome, an over-all view, either for an introduction or as a summary.
8. To arouse interest by introducing new material which will catch attention and lead to more effort and better learning.

Many writers have made lists of objectives like the one above and have then proceeded to lay down some rules for filmstrip making—but no one has ever made up a set of golden rules which will inevitably please and always achieve success. Nearly everyone has his own recipe for success—and the recipes vary a great deal, and those who have made them all stick by their own. There are, however, a few points about which one can feel some degree of certainty—if one has enough experience of teaching with visual aids. They are as follows:

1. Don't have a long strip with too many pictures—they are as mentally indigestible as too many words.

2. If you have bought a commercial strip with 30, 40 or 50 pictures, don't assume that they must all be looked at on a single occasion.

3. If your subject needs a lot of pictures, arrange them in groups, each devoted to one aspect of the subject—and deal with them group by group.

4. If you make your own strip, try to 'zone' it as follows:

(i) Introductory zone—a few key pictures of each main stage arranged at the beginning of the strip as an over-all introduction.

(ii) Second zone, dealing with Stage One in, say, a group of six pictures of which the first is the 'key' to the group.

(iii) Third zone: Stage Two, with a key picture.

(iv) Fourth, fifth, etc. zones.

(v) Last zone, a brief recapitulation by a set of key pictures, but preferably not exactly the same as those already used.

Make short strips when possible—they do not overload the pupil and are more easily handled in amateur production. Each of the zones referred to above could be dealt with on a short strip.

Diagrams should be boldly drawn with clear lines and the lettering should be easily read from the back of the class.

If any frames consist only of printed verbal matter be sure that it is of minimal amount, easily understood and clearly visible.

Remember that for some purposes a whole collection of pictures may be necessary as a sort of library or reference volume—and do not hesitate to make such a collection—but do not try to force an artificial pattern on it along the lines described above.

Probably the best way to help a beginner to plan a filmstrip is to take a few examples and work them out—for instance the following:

A. A strip to trace a process stage by stage from start to finish—e.g. making a model.

B. A strip to explain a relationship which is not easily grasped—e.g. why a Mercator map distorts land shape and area.

C. A strip to extend understanding of conditions quite outside experience—e.g. showing an Indian child what Arctic life is like.

D. A strip to relate together a series of complex facts—e.g. the coconut and its place in tropical economy.

Making each of these will involve three stages:

1. Planning the sequence and content.
2. Preparing the original material, making models, diagrams, etc.
3. Carrying out the photographic processes.

Stage 3 we have dealt with briefly in the first half of this chapter. Stage 2 is mostly covered in other chapters (IX, X and XI). We thus have now to deal with Stage 1, depending mostly upon our own opinion as to what is best, trying to learn by experience so that later results shall be better, and keeping in mind what has been said in various parts of this book about visual learning.

In *A,* the first of our examples, we have a straightforward case of following a process step by step in order to show how it is done. The order of events is dictated by the subject and by the mechanical processes involved. The only control we may need to exert is to decide that, because special difficulties arise at certain points, we ought to give these a heavier emphasis than others. We should also note a very important point which has reference to every learning situation. As teachers, in virtue of our skills, knowledge and maturity, we can get an over-all picture of a process as a whole, which is denied to our pupils who are immature. Even if we are only given bits of the process, one by one, we can construct for ourselves some conception of the whole. Not so the pupil; if we give him a bit only, or if we go stage by stage through a process, he may get no over-all view until the end. He has not been able to anticipate, to see the relations of one step to another, nor to appreciate that there is a logic of dependence in the order of events —that until a particular step has been dealt with some other operation cannot be performed. This is not merely a point to notice in making a filmstrip, it is also a step in good teaching and, with this in mind, we can now turn to actual details.

As our example we take the preparation of a very simple filmstrip which shows how to make a simple model boat—a model which would be of considerable interest to boys and girls, and which is made from simple materials by processes requiring little skill. The steps in making the filmstrip could be adapted to any similar job, such as making a model house, an electric motor, a model of a cart, and so on.

First we need to decide how our material is to be disposed between the filmstrip and an explanatory note. Let us start with the latter, which might well be arranged as shown here.

1. *The Explanatory or Teaching Note*

(i) Short description of the model as representing a particular type used for fishing, etc.

(ii) List of tools required.

(iii) List of materials required.

(iv) Order in which work is to be done: cut out bottom of hull and keel; cut out sides and deck; make mast and sail; assembly; painting.

(v) Points which require special attention: getting the various angles correct; setting up the frames; stepping the mast; marking the water-line; getting a good finish on the paint; hints on sailing the model.

(vi) Working plan.

(vii) Frame-by-frame comment on the strip.

2. *The Filmstrip*

It may be useful to remind ourselves here of certain basic points:

(i) Our pictures need not, and perhaps cannot, deal with everything in a process. We must select the most profitable minimum.

(ii) We should illustrate only that which needs explanation, analysis, etc.

(iii) We can make use of many devices to help us, apart from pure representation.

(iv) We must seek a happy union of the logic of method and of understanding.

Therefore we should at once make certain decisions:

(*a*) We do not need to illustrate materials and tools in this case—though for other processes we may.

(*b*) We must give, at once, some clear understanding of the whole.

(*c*) We cannot use a filmstrip to present a detailed working drawing for use at the bench.

An appropriate layout for our strip would then appear to be:

	Frame	*Content*	*Purpose*
PART 1	1	View of complete model.	Arouse interest. Give general idea.
To gain general idea of whole scheme.	2	Diagram of 'exploded' model.	Appreciation of the relations of parts to the whole.
	3	Diagram of separate parts of hull in plan views.	Appreciation of relations of parts to each other.
PART 2	4	Assembly: (i) bottom and keel with mast heel step.	To show how the sequence of assembly depends upon the logic of structure.
To gain idea of work sequence.	5	Assembly: (ii) ditto plus bow, stern and sections.	
	6	Assembly: (iii) ditto plus deck, rudder and mast.	
	7	Assembly: (iv) ditto plus sail and rigging.	
PART 3	8	Marking out bottom of hull.	To show method which can be adapted for subsequent use with other parts, e.g. deck.
Dealing with special points.	9	Cutting out bottom of hull.	To show how careful cutting can reduce later work.
	10	Methods of testing bevel and angles.	To get accuracy in hull form.
	11	Method of bending hull sides into position.	To overcome a difficulty without a special cramp.
	12	Fastening deck into position.	To obtain a watertight joint.
	13	Screwing deck with screws at an angle.	Ditto
PART 4	14	Drawing covering board, planking.	To get neat lines, etc. at proper place.
Finishing the model.	15	Finishing hull with paint.	Ditto
	16	Making the mast.	Making a circular mast from a square.
	17	Making the sail.	Pattern and sewing.

	Frame	*Content*	*Purpose*
PART 5 Sailing the model.	18	Diagram of sailing.	To get a general idea of sailing points.
	19	'Running' before wind.	To illustrate the points of sailing.
	20	'Reaching' across wind.	Ditto
	21	'Beating' to windward.	Ditto

This scheme, in general terms, could be adapted to many other topics. Making a model relief map of the neighbourhood, teaching the stages in a dissection, showing how to blow a T piece in glass, or demonstrating a simple scientific experiment are examples which require simple serial treatment—with that degree of modification of order and arrangement which will give real understanding.

Having worked out the content of the strip we are now left with two jobs : the practical task of making the illustrative material, and the photographic process. In our example it would be possible to use nothing but drawings —if we are able to make them—and if we could do so the whole process could be done on a blackboard. It would probably be better to use diagrams and photographs, and here—and for the subsequent process of printing the strip—we can refer to what has been dealt with in other parts of this book.

As a second example we take the case of map projection, which presents the pupil with many difficulties and can only be understood when one has some realization of a number of complexities. It is quite clear that many pupils have a remembered knowledge of the characteristics of maps—but little understanding. If this is to be gained they must be able to appreciate the difficulties of representing on a plane surface what exists on the curved globe, and they must also appreciate that the distortion which comes from projection is of different degree at different positions.

Opinions as to how this problem should be tackled are many, as may be seen in the various attempts which have been made. The method proposed here rests first upon the points already made, and secondly on the need to work in terms of what is possible for the amateur producer.

Thirdly, it rests upon a particular interpretation of the pupil's needs in this connexion. How should one arrive at this? If we leave out the needs of those likely to become professional geographers, and those who will be specially trained to make specialist use of maps or charts (e.g. pilots and navigators on sea and in the air) we can ask who else has such needs, and what are these needs. We are left of course with the 'man in the street', who at most will use a map as an adjunct of reading or in relation to his personal travel. Though his needs will be mostly related to the use of maps, that is, to map-reading, it must be remembered that he ought to have enough background knowledge of maps to enable him to appreciate something of their characteristics. As literacy increases and political interest grows, there is an increasing chance of meeting arguments in print supported by maps. Questions of economics, resources, land availability, sovereignty and 'possessions' loom large today, and astute choice of a projection soon discloses an inequality which is apparent rather than real, a function of a projection, not a quality of reality. This suggests the need to understand a little about distortion. Similarly, in these days of air travel, the man in the street should surely know what a 'great circle' is, or about relative position and direction. And it may well be that the days of space travel, now dawning, will bring other more complex needs.

As the background to all this it will at once appear that the map-maker is faced with (among many others) four particular problems:

1. How to show distance on a map so that the scale is constant all over the map.
2. How to show direction so that relative positions, all over his map, are those of the land itself.
3. How to show areas so that the scale of area is constant.
4. How to preserve shape so that it reflects reality.

Though the map-maker and the student of geography are aware of these problems, our hypothetical man in the street is not. Our task is to make him aware. This suggests that we must not only catch him young, while he is at school, but also hit him hard—in a metaphorical sense. For this reason it is suggested that a filmstrip on this topic should start by posing the problem. Moreover, in doing so an attempt should be made to include local reference and demand some sort of practical response.

Here then is a first draft for a filmstrip, one which will require the adding of local colour. Also one which in fact could be prepared as a series of drawings, tracings and diagrams without much skill, and if they cannot be converted to strip form they might be stuck up as a chart on the wall.

PART 1

	Frame	*Content*	*Purpose*
The problem stated.	1	Outline maps of selected areas, e.g. Greenland and South India—or Alaska and U.S.A. Superimposed if desirable.	To show apparent differences or similarities (according to example).

	Frame	*Content*	*Purpose*
	2	Tabulated basic data, e.g. length . . . miles . . . degrees width . . . miles . . . degrees area . . . square miles.	To diagnose *actual* differences or similarities.
	3	Data from *maps,* stated in scale units or proportion. e.g. *A* *B* 1 unit 2.3 units	To pose basic problems: why do countries so alike appear so different on the map (or reverse)?
PART 2 The data with which a map must deal.	4	Distance—illustrated by use of scales for local area.	To show that scale is selected to suit purpose.
	5	Direction—illustrated by use of diagram of bearings between local towns.	To show that the map must preserve the relative positions.
	6	Area—map of local fields, village, province, etc.	To show that what is larger in fact must be larger on the map, and in the same proportion.
	7	Shape—maps as in (6), on differing scales.	To show that shape is preserved irrespective of scale.
PART 3 The map-maker's difficulty to show a curved surface on a flat plane.	8	A ball, with area X, and a square of same area.	To emphasize that area is a function of surface, not only of shape.
	9	The hollow ball, cut in half, and flattened, to show cracking and 'splaying' of surface.	To show that a hemisphere when flattened may preserve its area, but does not retain regularity of shape and becomes distorted.
	10	A sphere enclosed in a cylinder with two equal segments of the former projected to the walls of the latter, one segment on the equator, another at a high latitude.	To show that this kind of projection leads to distortion, the upper projection being disproportionate to the lower.

	Frame	*Content*	*Purpose*
PART 4 Attempts at solution.	11	Diagram of equal area cylindrical projection.	To show that area is true to scale but that shape is distorted in north and south.
	12	Maps on equal area cylindrical projection.	To show above in comparative terms.
	13	(i) Diagram of rectangle with two points *A* and *B*, the latter to be NE. (or other bearing) of *A*. (ii) Ditto with one dimension $\times 2$. (iii) Ditto with both demisions $\times 2$.	To show that scales must be altered equally along both axes to preserve relationships of position.
	14	Mercator world map.	Preserves shapes (i.e. relationship of position) but distorts area at high latitudes.
	15	Molleweide world map.	To show reduced distortion of shape and preservation of areas.
PART 5 Applications and choice of projections.	16	Comparative maps of such areas as:	To show need to choose which factors must be preserved and which can be neglected regarding area, shape, etc.
	17	Alaska, Greenland.	
	18	India, Australia, New Zealand, each on different projection.	

There are of course many other projections, but these few indicate the nature of the problem, which will only be understood by the pupil if he is helped by notes, talks, discussions and practical work, though this may only take the form of critically examining a series of maps, or preparing maps of distribution on different projections and comparing the apparent results. Only by using such a strip and suitable exercises will there be an appreciation of why Cylindrical Equal Area may be suited for tropical crops, but not for showing extreme northern or southern land-shapes—or why discussions of *Lebensraum* are illustrated on one projection rather than another.

Next we take a different type of problem, showing the pupil something which is quite outside his own direct experience, such as how people live in the Arctic. A problem of this kind is too often handled as though it was not a problem, but a mere piece of visual description. The visual description should be thought of as the answer to a problem and we must make it our job to set the problem. To do this we have at our disposal three things—discussion, reading matter and the filmstrip. It is a nice point to decide at what stage one uses these and in what order. Discussion cannot profitably be engaged in unless one has something to talk about and think about. In the case we have postulated we must therefore either provide descriptive talk ourselves, or provide reading materials or visual materials. We could therefore make a filmstrip and use it as our starting point—and at once we run into the practical problem of getting the materials. Obviously we must, in the majority of such examples, rely upon pictorial material cut out from magazines or copied from books—our first step must be to ensure that such sources are available to us. With the photographic copying we have already dealt earlier. If such materials are not available—and if we have knowledge and skill—we can make drawings on the blackboard or on paper and photograph these. However, our concern here is with the question of the content of the strip rather than with the technique of its preparation.

It would seem appropriate to work along such a line as follows—noting that we must take the known and already experienced as a step towards the unknown. First we decide what are the major problems, e.g.:

1. Where is the Arctic region?
2. What are its characteristics?
3. What does it look like?
4. What special problems does it set for those who live there?
5. What peoples live in the Arctic?

These five major questions might be used to form the main parts of our filmstrip. Our next problem would then be that of deciding how to illustrate each—remembering that we can make use of explanatory notes, description and discussion and visual material. Let us now take our sections:

	Questions	*Frame*	*Content*
PART 1	Where is the Arctic?	1	Arctic seen on globe from equatorial position.
		2	Arctic seen in plan from polar position.
PART 2	What are its characteristics?		
	Temperature.	3	Isotherms.
	Seasons.	4	Long winter, short days.
		5	Short summer, long days.
PART 3	What does it look like?	6	Taiga.
		7	Tundra.
		8	Snowscapes.
		9	Sea ice.

Questions	*Frame*	*Content*
PART 4 What special problems does it set?		
Shelter.	10	*Igloo.*
	11	Summer hut.
Food.	12	Sealing.
	13	Fishing.
Clothing.	14	Skins.
Transport.	15	*Pulka* and reindeer.
	16	Sledge & dog team.
	17	*Kayak.*
	18	*Umiak.*
Heating.	19	Drift-wood fire.
Lighting.	20	Oil lamps.
Shortage of materials.	21	Bone arrow-head, harpoon, fish-hooks.
	22	Glass and flint collected on beaches and used for knives and scrapers.
PART 5 What people live there?		
Distribution.	23	Map.
Types of people.	24	Eskimo.
	25	Polar Indians.
	26	Lapps.
Modern immigrants.	27	Siberian.

It is not suggested that this is an ideal strip; in fact it reflects what the writer found available when he wanted to tell tropical children something about an entirely different kind of life. But at least it suggests a way of approach and a method which can be used to seek a better solution to the same problem or be adapted to some other situation.

For our last example we take a problem which is complex but set in the tropical child's own environment—the coconut palm and its significance for life as a whole in Ceylon. To a child from the seaboard and low country of Ceylon the coconut palm is one of the commonest objects around him, one on which he depends in many direct and indirect ways, and one which seems almost to be ignored because education is verbalized, academic and centred in the abstract rather than in the concrete things of the environment. As the subject is treated here, the aim is to focus attention on such points as:

1. The importance of common, everyday things.
2. The varied contributions from a single source.
3. The influence of available materials on ways of doing things.
4. The social significance of the coconut in ways of living.
5. The interdependence of local regions for materials from a common source.
6. The effect on local economy of world demand for a local product.
7. The impact of science (as agriculture, etc.) on society.

This is not material only for a filmstrip—it is almost a study of the whole of human society in a tropical setting. It is not material for a single lesson, but for a term or even more. Nor is it material only to be looked at—it should be the basis of project and activity work. The filmstrip should merely be a single means towards an end—social education—understanding the society in which one lives. Finally it must be noted that this is not a rigid formula. This is a treatment devised by someone who can perhaps never appreciate to the full the way in which a single source of raw material gives a pattern to social organization. It must then, even more than the other filmstrips, be taken not as a model to be copied but as an idea to be modified.

Frame	*Content*	*Purpose and Comments*
1	Picture of coconut trees.	Introduce subject by emphasizing that so common a tree as the coconut presents problems, because it is the basis of a way of life.

Frame	*Content*	*Purpose and Comments*
2	Picture of crown of tree to show fruit, flowers, etc.	Focus attention on central theme and show basis of reproduction and succession of crops.
3	Picture of the nut.	Should be backed up by having actual nut in class.
4	Section through nut.	Demonstrate. Allow more detailed study of structure of nut.
5	Boy drinking juice.	One product is used as drink.
6	Woman scraping flesh from inside.	Age-old method—use of product for domestic cooking.
7	Case of 'desiccated coconut'.	Emphasize export of desiccated coconut, spread of a food habit elsewhere, dependent upon method of preparation and development of transport and trade.
8	Picture of biscuit packets, confections, etc.	Commercial use of coconut in foods.
9	Picture of mill for grinding *chekku*.	Method of extracting oil from nut.
10	Picture of cattle eating *poonac* (residue after extracting oil).	Use of residuary materials which were once looked on as waste—link with animal husbandry.
11	Girl plaiting leaves on fronds to make *cadjan*.	Use of fronds to make roof covering for protection and privacy.
12	Building house roof.	Use of coconut timber in rood rafters.
13	Furniture.	Use of coconut timber in furniture trade.
14	Beating husk to make fibre, the first stage of coir, etc.	Use of a natural fibre an important basis of social life and economics.
15	Making coir rope.	Ditto
16	Making coir mats.	Ditto
17	Making sweeping brooms.	Ditto
18	Composite frame, articles based on use of shell.	Use of the shell to produce buttons, containers, spoons, etc.
19	Heating shell pieces.	Production of acetic acid.
20	Composite frame—coconut as a fuel.	Use of wood for domestic fire fuel, shell as fuel, charcoal, etc., and oil in lamps for illumination.

Frame	*Content*	*Purpose and Comments*
21	Toddy tapping—showing receptacle to collect sap from developing flower.	Use of sap.
22	Jars of arrack, toddy, vinegar and jaggery.	Products of sap, by fermentation and crystallization.
23 & 24	Tabulation of parts of the coconut tree and their uses.	To show that all parts of the tree are utilized and that the products are the basis of a whole economy and way of living.
25	Tabulated data—world imports of copra (the dried flesh, used to extract oil, etc.)	To show that there is a world demand for a natural product, which is already a basis of a local economy.
26	Tabulated data—exports from coconut areas all over tropics.	To show competition by other countries in the coconut products trade.
27	Map of Ceylon.	Distribution of coconut growing areas.
28	World map.	Coconut areas of the world.

The material given here is the first draft for the content of a trial filmstrip and an explanatory leaflet in the form of a frame-by-frame commentary. The general content and method of treatment was worked out along lines already suggested for our other examples. The subject and a note about each frame was then decided upon and a rough sketch made to indicate the type of picture required. These are not reproduced here but were in fact used as a guide for taking the necessary photographs.

With the foregoing examples as a guide the beginner should be able to tackle the production of filmstrips of different kinds. Lack of technical resources will probably mean that only simple work can be undertaken, but this is in many ways an advantage. In any case simplicity should be aimed at, for an overloaded, complex strip will do little beyond overloading the pupil. For very many purposes six or even four frames will provide material for a whole lesson—even more sometimes, Before leaving the filmstrip there are a few other points to be noticed. Many teachers, however willing and anxious to use filmstrips, will find that cost and the lack of technical resources will prevent them from doing so. Even if this is so there is no reason for not attempting some kind of visual approach. All the arguments and examples dealt with above can be modified and applied to other methods of presentation. One could make a folder containing the visual material and the teaching notes and use it as a class reference book. Where an episcope is available the visual material could be prepared on postcards and these could then be projected in the right order, indeed they could even be mounted on a long strip of paper and thus form an 'episcope strip'. The important thing is to think of visual education as a means of approach, and not merely in terms of presentation as strip or chart. It is the method in general, not the method in detail, which matters.

Among those who are not able to make their own filmstrips there will be some who may be in a position to buy them. They will be catered for by the commercial producer and will find a very wide variety of material available for them. In some areas there are filmstrip libraries which charge moderate rentals, and in other places the education authority may have its own library. The teacher should make certain that he has explored all these possibilities completely. In order to reduce costs of commercial purchases, schools can club together in common ownership. This is particularly well worth consideration where a strip has to be made specially for local needs—the greater the number of copies purchased the lower the cost of each.

It should also be noted that a filmstrip can be used to make visual material in other forms. Any particularly useful picture, map or diagram can be projected and drawn on to a sheet of paper and then finished off in colour or black and white. This technique could be used particularly well, for example, in relation to the equipping of the schools of an area with a sufficiency of maps. In Ceylon, as doubtless in India and elsewhere, few schools have enough maps of their own country. The state department of education, or even the larger schools, could sponsor or undertake the production of a map filmstrip. This could then be circulated round the schools and used to prepare a set of large-scale wall maps. Exactly the same method could be applied to many other subjects. In each case the important points to notice are:

1. A well-considered scheme should be the basis of the strip to ensure that it meets everyone's needs and covers the subject.

2. The original drawings should be clear and bold with easily read lettering.

3. Maps which are to be photographed (or other material) can be worked on with indian ink, Chinese white, etc. to emphasize detail.

4. All maps should show scale and orientation.

5. When showing a special region on a larger scale it is desirable to insert a small-scale outline map of the whole country on which the special region is shown in black.

6. As far as possible keep to a standardized scheme of symbols, lettering and other forms of coding.

7. When the maps have been enlarged into a large-sized pencil drawing, write in all lettering and symbols in pencil and check with care. Then paint with a series of light washes of colour and finally ink the lettering and outlines, etc. on top of the paint.

A basic scheme for the layout of such a map strip which could be adapted to most countries is as follows:

PART 1	The position of the country.	*Frame* 1	Position on Mercator projection showing land and sea routes.
		2	Position on Azimuthal projection showing air routes of the world.
		3	Position in relation to own continent.
		4	Position in relation to contiguous countries.
PART 2	Basic geography of the country.	5	Physical relief model, oblique view.
		6	Contour map.
		7	Vertical sections.
		8	Surface geology.
		9	Solid geology.
PART 3	Climate.	10	Temperature distribution.
		11	Rainfall map.
		12	Charts of climatic data.
PART 4	Regional geography.	13	Natural vegetation zones.
		14	Natural regions.
PART 5	Mineral resources.	15	Cultivated areas.
		16	Metallic ores.
		17	Oils and coal.
		18	Stone quarrying.
		19	Important sands, clays, etc.
		20	Salts and other chemicals.
PART 6	Human geography.	21	Distribution of population.
		22	Types of settlement.
		23	Industrial and rural activities.
		24	Major communications.
		25	Administrative divisions.

It will at once be seen that such a map strip makes it possible for every school to have a set of large-scale maps which cover all the main geographical features in a way which cannot be done when relying only upon textbook diagrams and atlas maps. This is but one idea for a subject not well treated in the textbook—there are very many others. It may stimulate interest to suggest a few more subjects, such as the following:

Local historical remains.
Changes in the distribution and size of local population.
Local industries.
Local arts and crafts.
Tank and irrigation schemes.
Water-supply.
Local agricultural methods.
Health and factors which affect it locally.
Local customs.
Local social service work.
How the local region is governed.
'Our School' and what it does.
'Our Problems'—and how we might tackle them.

We finish this chapter with a very brief reference to the making of moving-picture films—an activity which is not common among the well-paid teachers of the West and is likely to be less common still in the East.

While sub-standard films can be made on 8mm, 9·5mm or 16mm film, it is always preferable to use the 16mm because this size is universally adopted for educational work. Amateur work is generally on silent film because sound recording equipment is highly expensive and the cost of putting a spoken commentary on a film is considerable even when it can be recorded in the studio. Because of the high cost of colour film most amateur work is done in black and white. Reversible film is usually used, but this has the disadvantage that only one copy is usually available, because the film exposed in the camera is itself developed into a positive by chemical reversal. It is preferable to work with negative film developed as a negative from which a positive copy is printed.

It may be convenient to tabulate the general stages in the making of an educational film of simple type. These are, in general, as follows :

Main Stages in Making an Educational Film

N.B.—This is based on procedure adopted in the making of a 10-minute sound film on *Separative Processes.* The film was planned by members of the scientific administrative and inspectorial staff of the State Department of Education of Ceylon, in conjunction with UNESCO Consultants on Science Teaching. Production was undertaken by the Government of Ceylon Film Unit. The original was on 35mm and the final version reduced to 16mm for school use.

1. *Defining the Problem*

The introduction of general science, and the effective use of such science education in social development, demands an appreciation of the fact that science is a part of daily life in our normal environment.

To emphasize this it was decided to select a topic which related to everyday life and which led to activity in the 'domestic setting', but which was also of significance in the laboratory. Such a topic was found in *Separative Processes.*

The domestic situation, especially in a tropical setting with a manual culture depending upon direct products (e.g. domestic economy making little use of commercially prepared food materials), makes use of many methods of separating constituents in kitchen and field. Similar methods, becoming more and more refined, are used in science and its applications in industry.

2. *Planning the Content of the Film*

Lists were made to show separative processes in:

- farming—the basis of food production
- cooking—the sphere of food preparation
- gemming—a local little-industrialized industry
- water-supply—a significant organized activity in social life
- hospitals—a situation demanding particular emphasis upon purity, cleanliness, etc.
- engineering (transport)—the development of transport has made many rural folk familiar with the use of petrol and oil as fuel in the car and motor-bus
- laboratories—with which few people in under-developed countries have any familiarity
- industrial science—where acquaintance is even more limited.

3. *Scripting the Film*

This was carried out in two stages:

(i) A continuous argument was developed, primarily by the scientific staff of the team, which set out the story of separation and its significance. This traced the process from simple to complex, and from farm and kitchen to laboratory and workshop.

(ii) The above material was handed over to the science teachers for discussion on presentation from the teaching angle. As a result of this a continuous narrative (commentary) was written and suggestions made as to how each point should be illustrated.

4. *Shooting the Film*

Locations, times, procedures, personnel were all determined in advance with regard to economy of time, travel and material. On this basis the camera crew and director went to work on the sequences.

5. *Cutting, Editing, Recording, etc.*

Each sequence was examined in detail and appropriate material taken out. From this, using the shooting script, a first draft version was made.

This was 'cut' with regard to educational aspect and the time factor.

A viewing committee analysed the result and suggested some rearrangements which were incorporated.

The sound-track was added and the film was ready for try-out work in the schools. In the light of classroom use modifications may prove desirable.

It may be noted that this is a very brief description of what proved to be an arduous task, also that much has been left out, particularly of the special jargon which film-makers use among themselves!

The final script of the film is analysed below:

Script for 10-minute sound film

SEPARATIVE PROCESSES

Sequence	*Shots*	*Time in seconds*	*Commentary*
A. Introductory review of processes	1. Farmer separating paddy from chaff (long shot, low angle).	5	All over Ceylon we see men in the fields using time-honoured ways of getting paddy free from chaff,
	2. Girl filtering coconut milk (close-up).	5	and women in their kitchens separating the milk from the coconut scrapings.

Sequence	*Shots*	*Time in seconds*	*Commentary*
	3. Children playing on sea-shore (long shot, tracking to close-up of sand and hands).	15	And when children play on the sands they can see that Nature herself has often separated one kind of sand from another, making layers of different colours.
	4. Laboratory worker with filtration apparatus (medium close-up).	5	Separative processes, which we all know so well, are very important to the scientist, whose methods have come from the simple ones we know.
	5. Girl winnowing rice (medium close-up).	10	From the girl winnowing rice,
	6. Girl washing rice (medium close-up).	5	and washing the stones away have come the refined methods used by scientists in their laboratories.
	7. Farmer winnowing rice (repeat of 1).	5	Here is the farmer again, using the experience of the ages, gravity pulling the heavy grains downwards, and the wind blowing the chaff away, as you see
	8. Diagram.	10	in this diagram,
	Table build-up	15	and in this list of how we use separative processes to separate :
Add titles one by one to build up table.	9. SOLIDS from SOLIDS		Solids from solids.
	10. SOLIDS ,, LIQUIDS		Solids from liquids.
	11. LIQUIDS ,, LIQUIDS		Liquids from liquids.
	12. SOLIDS ,, GASES		Solids from gases, or
	13. LIQUIDS ,, GASES		liquids from gases.

Sequence	*Shots*	*Time in seconds*	*Commentary*
B. Sedimentation processes	14. Adding water to soil in jar (close-up).	15	Nature separated the sands, and we can separate the different parts in the soil by adding water, shaking it up and letting it settle, and there are the various layers.
	15. Shaking jar (close-up).		
	16. Various layers (extreme close-up).		
	17. Hand-picking stones from rice (close-up).	5	Or we can separate out solids by simple hand-picking, as this girl is doing.
C. Magnetic Separation	18. General view of machine (medium close-up).	3	Here is a powerful magnetic separator,
	19. Coils (close-up).	3	with its heavy wire coils.
	20. Pouring sand into receptor funnel (close-up).	3	The sand mixture is poured in here,
	21. Separating channels (close-up).	3	to go through these channels between the magnets
	22. To the delivery spouts (close-up).	3	to the delivery spouts.
	23. Diagram.	10	Here is a diagram of how it works.
D. Decantation	24. Decanting liquid off solid (medium close-up).	7	A simple way of separating a liquid from a solid is just to pour off the liquid by decanting.
E. Filtration	25. Filtering coconut milk.	5	But a more efficient way is to use a filter, as this girl is doing.
	26. Filter on tank in car (close-up).	8	We filter the petrol for the car engine as it is poured into the tank,
	27. Fuel-line filter (close-up—show how to unscrew and assemble).	20	and again before it reaches the engine. Here is the special glass filter which is used to do this,

Sequence	*Shots*	*Time in seconds*	*Commentary*
	28. Diagrams of filters.	10	and here are diagrams of these filters to show how they work.
	29. Folding filter-paper (close-up).	10	In the laboratory we use a filter-paper, folded like this,
	30. Placing in funnel (close-up).	5	and placed in a glass funnel.
	31. Wetting the paper (close-up).	5	Then we wet it with water,
	32. Filtration (medium close-up).	20	and next pour the fluid into the funnel.
	33. Pressure filter apparatus (near long shot of whole set-up).	10	Some scientists use special filters, like this one.
	34. Filter unit (close-up).	5	Here is the actual filter case,
	35. Filter pad (extreme close-up).	5	and here is the filter pad.
F. Water purification by filtration	36. Lifting sluices at reservoir (long shot).	5	Filtration is very important in water purification, both in the home and in the town waterworks.
	37. Sluice gates (medium shot).	5	Water engineers use a sand filter
	38. Valves to sand filter (medium shot).	5	with valves to control
	39. Water entering sand filter (medium).	5	the flow of water
	40. Sand surface (medium).	5	into the sand.
	41. Diagram of slow sand filter.	10	This diagram shows the process.
	42. General view of pressure filter shed (long shot).	5	Sometimes they use high pressure filters, like these.
	43. Control valves—hand turning wheel (close-up).	5	Here are the control valves
	44. Pressure gauge—show needle (extreme close-up).	5	and the pressure gauge,

Sequence	*Shots*	*Time in seconds*	*Commentary*
	45. Diagram of pressure filter.	5	and here you see how it works.
	46. Aeration jets—rise and fall of water (long shot).	5	Finally the water is blown into the air to aerate it.
G. Centrifuge Separation	47. Putting tube into centrifuge bucket (medium shot).	5	We also use other forces to separate a heavy solid from a liquid—by whirling them around in a hand centrifuge
	48. Whirling (medium shot).	5	like this, and
	49. Tube with solids at bottom (extreme close-up).	5	here is the tube with the solids at the bottom.
	50. Shaking tube (extreme close-up).	5	Electric centrifuges are more efficient. First shake up the fluid in the tube,
	51. Inserting in bucket (extreme close-up).	5	then put it into the bucket
	52. Starting centrifuge (medium shot).	5	and whirl it around at very high speed so that centrifugal force throws the solids outwards
	53. Centrifuge slowing (medium shot).		
	54. Examining tube (extreme close-up).	5	to the bottom of the tube.
H. Liquids from liquids	55. Separating oil from water with a spoon (close-up).	15	Now we have seen solids separated from solids, and solids from liquids. Here is how to separate one liquid from another with a spoon.
	56. Separating through funnel, using finger (close-up).	10	But in the lab we can use a funnel and a finger to control the flow,
	57. Ditto—rubber tube with finger control (medium shot).	10	though a piece of rubber tube, pinched between the fingers, gives better control,

Sequence	*Shots*	*Time in seconds*	*Commentary*
	58. Ditto—with screw clamp (close-up).	10	and a screw clip is even more efficient.
	59. Separating funnel in use (medium shot).	5	Best of all is a glass separating funnel, with a stop cock.
I. Solids and liquids from gases	60. Bacteriologists using nose-guards (long shot).	5	To separate solid dust or germs, or water droplets from the air, we can use a nose-guard,
	61. Closing culture tubes with cotton plugs (medium shot).	5	or a wad of cotton wool.
	62. Air-cleaner or car engine (close-up).	10	Even the air sucked into a motor car engine must be filtered to remove dust particles.
J. Résumé	63. (Build up tabulation)		Now we have seen how important separative processes are in nature,
	NATURE sand layers. rock layers.	8	where sands and soils are separated in sedimentation ;
	FARMS paddy from chaff.	5	and on our farms, where the farmer uses gravity and wind ;
	HOMES milk from coconut, stones from rice.	10	and in our homes ;
	LABS filters. centrifuge. separating funnel.	8	or in laboratories, where scientists use the filter, the centrifuge, and the separating funnel,

Sequence	*Shots*	*Time in seconds*	*Commentary*
	INDUSTRY water purification. oil filtration. air cleaning.	8	and in industry where we filter oil and clean air and do many other such things.
	64. (Build up tabulation)		So now we have seen the four main kinds of separative processes.
	1. SOLIDS from SOLIDS sedimentation. winnowing. hand-picking.	20	First, solids from solids; sand from sand, paddy from chaff, or stones from rice.
	2. SOLIDS from LIQUIDS decanting. filtering. centrifuging.	20	Second, solids from liquids: coconut from the milk, dirt from petrol, particles from water.
	3. LIQUIDS from LIQUIDS spoon-skimming. separation funnel.	20	Third, liquids from liquids: like oil from water, or cream from milk.
	4. SOLIDS } from LIQUIDS } GASES filtration.	20	Fourth, solids or liquids from gases with the nose-guard, the wool plug and the air-cleaner.

It should be noted that this is a simplified description of the script. Considerable detail had to be provided for each shot, in order that the camera crew and director should understand precisely what was required. Only by providing complete descriptions of each shot can waste of time and money be minimized. It may also be noted that the script leaves some forty seconds in hand, spare time which can be used up in cutting and editing to accommodate points requiring more than the anticipated allowance.

XIV

RESEARCH IN VISUAL EDUCATION

ALTHOUGH THE FACT that this book is of an introductory and elementary nature has been emphasized at several points, it is not to be assumed that a reference to research work should have no place in it. Whoever writes about visual education must be continuously aware of how little is known about many important problems and how much we are forced to rely upon purely subjective opinion in relation to both the making and the using of visual aids. If research is needed in the West it may well be considered an even more urgent need in the East, where visual education is only now starting to develop on a large scale. The writer cannot avoid reflecting Western viewpoints but, aided by the corrective of twelve years or more in the East, is well aware that what has been designed for the West cannot be taken over and applied directly to the East. One might well say that research on visual education is needed in India almost as a step in self-protection against the insidious attack of the entertainment film on Indian culture patterns. Educational research itself is not yet highly developed in India, but it has started and shows promise of progress along many lines. It is greatly to be hoped that attention will be paid to the problems of visual education, and it is the purpose of this chapter to give a short review of the more important aspects of this problem. It is not written for the experienced and expert investigator but for the teacher who, with graduate training and some experience of his job, should be in a position to make valuable contributions in this field. While it is true that educational research has tended to be restricted to training college and university, it is important that teachers should be encouraged to enter the research field. This is particularly true in education, where we are so greatly in need of research work on the problems of the classroom—and where teachers are in so favourable a position for carrying it out.

As this chapter, like the book as a whole, is written primarily for teachers, its content and arrangement are those which seemed most likely to be of use to the teacher. In general it aims at reviewing the main points and suggesting where more detailed and specific help can be found. We shall start by considering the nature of research; next we shall turn to consider what kinds of research can be done in visual education and the conditions which will be required to conduct them; finally we shall review some typical pieces of research on visual education and comment upon their implications.

The Nature of Research

It is important to understand what is meant by the word 'research'. This word is frequently used today by different kinds of people in different ways. Teachers and writers describing the work done in projects or other activity methods often refer to the 'research' done by their pupils; here they mean the collection of evidence and data, the use of library resources and the classification of observations. A somewhat similar use of the term is made by students who present lengthy essays based on 'research' which has involved the collection and classification of evidence. Many of the reports which are produced by local education authorities on such topics as school attendance problems, scholarship awards and the like are described as 'research'. In the two cases first named, those of the pupil and student, the investigators were collecting materials new to them which they were using as part of an essay or report in which they would present their personal findings and opinions. In the third case the data collected had been selected from existing records and described and analysed with the intention of making a factual report on a particular situation and without reference to any kind of personal point of view.

'Research' however has another meaning which is given to it by the academic worker. This meaning is not easy to define though it can be described in various ways. Used in this way it describes a study which is factual, in which opinion plays no part (or as little as possible) and which has been carried out according to very rigid rules to ensure that it is a truly representative study. Research in this sense is objective, there is no place for the subjective effects of opinion to enter in, its results can be shown to be free from errors within certain limits and they are obtainable to within a close degree of approximation by anyone else who uses the same methods of investigation. The research worker is a seeker after truth, he constructs a theory to fit his facts instead of searching only for facts to fit his theory. Research work, in this sense, can only be carried out according to certain safeguards.

To many people research work makes no appeal; indeed they are critical of its results and antagonistic to its methods. This is usually because they do not understand the methods employed and are not sufficiently rigorous in their methods of thought. They work in subjective rather than objective terms, they prefer their experience rather than the findings of what they consider to be an unnecessarily complex procedure. They are frequently ready to make predictions and judgements without evidence and equally ready to believe that such acts are justified by their personal knowledge, however limited the field from which it is drawn. It is important to realize that such methods, based only on subjective experience are not devoid of all value. Experience often begets wisdom and many people are remarkably skilled in 'having a hunch'. The time it takes to acquire it should give experience considerable value. The difficulty about using experience as our sole guide comes from its subjectivity, from the personal factor, which makes two people give entirely different interpretations of an experience they have shared under the same conditions.

Research is the attempt to cut the time lost in waiting on experience and, at the same time, to reach conclusions which are free from the influence of personal factors, which will hold true in other times and places, and which are free from error within certain definable limits. It is true that a more rigorous description of research would involve a great deal more than this, but even such simple statements provide a useful guide. With these in mind we can, for example, ask whether some of the claims made for their films by producers are justified. Or whether teachers' views about films reflect the truth. Or whether the producer who takes his 'rough cut' (a sort of first edition, a trial form) to the classroom to note class reactions will really get anything useful from it. Some people would accept such claims, views and rough-cut tests as valid. Others would not. To the latter class belong those whose investigations have been described already. This class is rapidly growing in number as more and more people begin to think critically about the use and value of visual aids. It is for them this review has been written as a guide which will help them to appreciate existing research work and indicate the lines on which they must go if they want to do such work themselves—as many teachers now do.

The conduct of research work on visual education will involve experimentation and the presentation of data in numerical terms. It will also involve critical thinking about this data, because data only acquires meaning through thought. The research worker in visual education will tend to ignore the purely qualitative and turn instead to quantitative study. This will introduce the use of measurement which involves a need for units in order to collect and present the data needed as evidence in the argument. Most of those who engage in research assume that measurement can be applied to education and that units exist which make this possible. While this question cannot be entered into here, it should be noted that measurement and units presuppose magnitude—but the existence of educational qualities possessed of magnitude is something the philosophers have not yet demonstrated. The 'practical' man dismisses this point and gets down to his research work; as this proceeds many have later been led to consider this purely philosophical problem as a matter of practical importance.

Evidence

Research, of the kind we are concerned with, needs evidence, which we collect as quantitative data and use as the raw material of argument. Collecting data is fatally easy, and easily fatal. It is obvious that we cannot collect *all* the data, so we must select, and on this selection success very largely depends. One cannot collect data and then seek a problem to solve. If the problem we see has no real existence, if the question we set out to answer is meaningless or irrelevant, no amount of data-collecting can result in worthwhile research. If the problem is real and the data irrelevant or unreliable, if any one step can be more important than others, is the first step—the design of the experimental procedure as a whole. This, which is a practical point, is usually learned by time-consuming experience, though it is hoped that attention to the points which follow may lead to its acceptance.

How can we collect our data? The answer will depend upon a number of factors, such as the type of problem, the kind of data we need, the availability of the materials involved, the number of pupils we have to work with, the time at our disposal and so on. Whatever methods we use it will be found that they usually conform to one or other of the following four types:

1. Analysis of existing records or of specially written materials.
2. Question and answer, either verbal or written.
3. Estimates and rating scales.
4. Specially constructed tests.

Each of these types has both good and bad points, and choice of one or the other should be a matter of careful consideration. Some of the points to be noted are as follows:

Type 1. There are unlikely to be existing written records of use in visual research except in the sense of previous publications. What the teacher will need is specially written materials, mostly perhaps in the form of essays, which he can analyse to find what he wants. What he wants, or perhaps what he might hope to get from such sources, would be data concerning the acquisition of information, the alteration of attitude and opinion or the extension of interests. Use of essays, however, is often—perhaps usually—very unreliable, although for some purposes they are the most easily used criteria—for example, in determining the achievement of style and continuity in English as compared with the same story presented verbally. If it is decided to use essays as sources of evidence, attention should be paid to various marking devices which have been described as attempts to improve effectiveness.

If the aim is a measure of information gained, it would be preferable to turn to Types 2 and 4. In connexion with the contribution of visual education to the extension of interests the essay may prove useful in following the origin and development of a single interest, but for the conduct of 'interest surveys' the methods described elsewhere would be more appropriate. For following changes of attitude and opinion the essay may have some value as collateral material, but the main work should depend on other methods falling under Types 2, 3 and 4.

Type 2. Questionnaire methods have proved extremely popular in educational investigations, though when faced with ignorance about a special point it is not inevitable that we shall get the truth by collecting answers from others who may in fact share our own ignorance! A number of simple points should be noted. A questionnaire should be as short as possible, consistent with getting what is needed. If it is too long the subject becomes bored or careless and, especially in younger pupils, may become fatigued. The questions should be simple and free from ambiguity, and should cover the subject equally on all sides, unless, of course, attention is specially devoted to a particular aspect. Questions including two clauses should always be avoided. It is considered essential by some authorities to vary the order of the questions, because there is a tendency by some people to confine their attention to some part of a line or column. With adult subjects a large number of factors, such as prejudice, enter into the situation and may influence their response. It is equally true that the investigator himself may unwillingly disclose a bias in constructing a questionnaire unless he takes precautions against so doing. Those who consider such points often make one or two trial 'runs' (or 'pilots') with a sample population similar to that with which it is finally intended to use the questionnaire.

Type 3. Estimates and rating scales have been used for various aspects of research in visual education, especially in connexion with film appraisal. The aim of those who design scales of this kind is to make it possible to get objective statements from one set of subjects about other subjects and objects. While the questionnaire provides a number of responses, devices of Type 3 usually allow the responses to be codified in some pattern or profile—they can be scored and often reduced to a 'point reading' on the scale used. Their potential value in visual research is considerable, and anyone proposing to work in this field should become acquainted with their general structure and use. For a general review of the methods involved together with critical notices of many well-known scales any work on psychological testing will be found useful. In particular consider their application over a wide field in psychology which may be suggestive in relation to visual research.

Type 4. Specially constructed tests can only be looked on as a separate group in the sense that the worker in the field of visual research will need to develop tests which relate to the kind of result and effect one can expect to follow from visual stimulation. These, as already pointed out, may be of several kinds, such as informational, attitudinal or in terms of interests. Many general tests in each of these fields already exist and the reader will find many of them reviewed in the works of Fryer (1931), Strong (1943) and many other workers, from which a knowledge of their construction and use can be obtained. Various special tests have been used in connexion with studies of the effect of the film on attitude and examples of these should be studied. The conduct of visual research will, however, as Carpenter has stated, need the development of special tests of its own, tests which take into account the special features of visual and audio-visual learning. A step in this direction has already been taken in England by Meredith who described a simple device for estimating the relative contribution of verbal and visual elements in a lesson.

Possible Faults of Data

The evidence required for research will be collected by one or other of the methods described above; this, however, does not ensure that it is acceptable. Our data can suffer from a number of faults which are too often overlooked by the research worker. Of the kinds of faults possible five should be mentioned—though, as almost the whole structure of statistical methodology has been built up to deal with faults, it will be realized also that only the briefest mention of each is possible.

1. *Semantic errors* are frequent in data because many of the words we use lack precise meaning and because words mean different things to different people. Far too little attention is paid to this problem by those who use visual aids, and perhaps even less by those who make them. The development of visual education has been characteristically subjective and the resulting opinions are

seldom made the subject of research. If semantic errors —the basis of verbal misunderstandings—are so important they should receive attention as a subject of research themselves. While it is true that the verbal content of sound films has been the subject of analysis, it is also true that the more fundamental philosophical aspects of the problem have been neglected.

2. *Statistical errors.* Many, even if not all, educational phenomena occur at some particular level or rate, at some particular intensity or in some particular frequency. Application of the concept of measurement to phenomenon is of real value ; our methods of measurement, however, suffer from defects and can often only be employed under imperfect conditions. Thus we usually have to rely upon indirect measurement, we have to use a measuring device which is not sufficiently sensitive, and we are often forced to use samples which are not representative. Measurements made under these conditions are approximations and the degree to which they vary from the real values are errors. To the statistician there are two kinds of such errors : (i) *Chance errors,* which are variable in terms of degree and direction and have a frequency of distribution which is 'normal', so that they tend to cancel each other out—their mean value being zero. (ii) *Systematic errors,* which operate in one direction only and thus tend to exert an additive effect through the presence of unrealized factors which affect all the responses of a subject or group of subjects in the same direction.

3. *Errors of sampling.* In many research situations the available experimental populations are too large, so that we have to make use of samples. In other cases the number of subjects available is perhaps very small. In either situation there is a danger that the sample we

select, or the one circumstances force us to use, is not representative of the total population. Should this be so the results of an investigation are vitiated from the start. The research worker will find it essential to become familiar with the theory of sampling and the statistical devices for dealing with possible sampling errors. It is a very common assumption that, merely by taking large enough numbers, errors of this kind will be avoided; this is not so, as will be seen from any statistical reference books. It is also worth noting that, in most situations, the investigator can calculate the number of cases he will require in order to ensure accuracy to a predetermined degree, as is shown for example by Vernon (1940). An important problem for those forced to work with small numbers is the danger of losing some of the cases (e.g. by illness, removal from school, etc.) before the investigation is completed.

The Fields of Research in Visual Education

'Visual Aids in Education' is so convenient a phrase that it has begun to be thought of as covering some defined and rather restricted field. This is far from true. The field is extremely wide, a fact which is to some extent responsible for the difficulty in making a start experienced by many would-be research workers. It is desirable that they should appreciate the wide extent of the field and have some understanding of its characteristics. For this reason it may be convenient to think of the whole subject as being divided up in such a way as follows:

1. *Technological Research.* There are very many problems in this division, but they are of a kind which can only be undertaken by those with special facilities and

skills. They are concerned mostly with buildings, apparatus and the raw materials of the visual aids processes. It would be a great improvement if projectors could be made less mechanically noisy, for example, by using a rotating prism as a shutter and a continuously moving film in place of the intermittent motion. Here we are in the field of engineering design. The improvement of colour photography or the development of stereoscopic projection present problems in other aspects of technology. Such work can only be undertaken by those with laboratory and workshop facilities, usually on the commercial scale. These development processes would impinge on research in our present sense only if they were subject to statistical analysis.

2. *Organizational Research.* The conduct of a visual aids service on a large scale involves a heavy expense and it is natural that this should be used to the best advantage. Here lies a field for research similar to the costing analysis undertaken by commercial films. In England we have tended to be content in education with general financial surveys of the cost-per-place type. In America costing research, and research into many allied administrative processes, has been taken much further. It seems certain that we could improve the efficiency of our services and make them more economical by attention to this field. Again, however, it is one with a limited and special appeal and one in which very few would have opportunity to work without access to records and data compiled by an administrative office.

3. *Physiological Research.* The visual approach depends fundamentally upon the physiological phenomena of vision. A great deal of useful research has been done on the mechanics of eye movement in reading; there is a need for similar research on related phenomena, for

example, in looking at projected pictures. In this field lie problems concerned with visual fatigue, intensity of illumination, thresholds of exposure for recognition, conditions for viewing, angular size of print, 'print load' per frame and so on. This also is a field which tends to need special facilities for its exploitation.

4. *Psychological Research*. It is here that we come into the field of research problems which are more specifically the concern of the teacher—as a user of visual aid materials. At the same time, it is also important that the maker of such aids should have an equal interest in this aspect. A situation cannot be considered as educationally sound in which a teacher is compelled to try to make good use of visual materials which are psychologically unsound in the first place. One must suspect that this in fact often happens. This field, the psychological aspect of visual aids, is of enormous extent and is one which offers many possibilities for research. It must, however, be realized that a first need is a thorough understanding of the major principles of psychology. Experience with many teachers who want to do research in visual aids suggests that, because of lack of sufficient psychological training, they tend to over-simplify the situation. A second need is for a grasp of, and competence in, the methods of statistics which will be described briefly later on.

5. *Pedagogical Research*. So far as pedagogical method can be differentiated from psychological principles (the division being one of convenience rather than of logic) it might be said that this field is concerned with the procedures of teaching rather than with the processes of learning. If one proposes to use visual aids it would appear to be important to determine whether one's pupils are 'visiles' rather than 'audiles'. In other words, while

most of them learn in both ways, it may be that some learn better from seeing things while others learn better from hearing about them. Here we might place such questions as to whether a film or strip carried too heavy a load of materials, whether pupil time spent on preview or orientation is worthwhile, whether watching a film about a skilled process can contribute to acquisition in that skill, and so on. This is the field in which the majority of teachers wish to work, but here also they tend to over-simplify and to look at their problems in too narrow a setting. For successful participation a knowledge of psychology is required, together with statistical training and a knowledge of the major findings of pedagogical research.

6. *Sociological Research.* If we interpret sociology as the study of the processes in society which mould attitudes and behaviour and which are concerned with the interaction between individuals and groups, we may well speak of a sociology of visual education. We have indeed already a number of studies of the sociology of the film, and, on this analogy, there is a place for development along other lines. Research in this field is likely to be of considerable value in its relation to social education, but it will be a task of some difficulty. Those who wish to work at it will need to be well acquainted with the principles of social psychology, with sociology and sociometry and with statistical procedures.

This classification suffers from some degree of over-simplification and its descriptions are too brief, so that there may appear to be clear-cut distinctions between ideas and approaches which, in fact, overlap to a considerable degree. It should, however, make clear a fundamental point which is often neglected. Research in the field of visual aids is research in the complicated fields of behaviour and learning. However simple it may look it will, from the educational viewpoint, be worthless (or almost so) if it neglects the child's point of view, the child's abilities, characteristics and general development. One cannot profitably compare the value of, say, sound and silent film except in relation to the psychological processes of children's minds. Visual aids in education are means to an end ; that end must be defined in terms of children in some way or other. If we neglect the child we change our visual aid from a means to an end in itself, we give it a false value. We have in fact ceased to be educationists and have turned into machine minders. Unfortunately this happens all too easily, because machines are less difficult to deal with than minds ! This is an important point, and, if teachers find it difficult to agree, it will be appreciated that film-makers and their confrères find it still more difficult. It is fatally easy to become lost in the technicalities and jargon of film production and to let them assume a status which is unjustified because it is artificial. It is true that, unaided (unhampered, he would say) by research, the film-maker has done some excellent work, just as the textbook writer or curriculum maker has. In doing so he has allowed virtuosity to exploit technique to the point of pretentiousness, and in doing this the cost of visual aids has gone far higher than it need have done. It will ultimately be of value to all concerned if research on visual aids is undertaken on a large scale, so that we may begin to know that even if our 'hunches' are sometimes happy, they are always haphazard.

The Conditions required for Research in Visual Education

It is unfortunate but true that the conduct of research work in any field of study goes on against a series of limiting factors. Of these factors the question of finance comes first to mind, and then that of research personnel—though the two are of course related. We cannot, in a book of this nature, enter into a discussion of these factors, important as they are, because they are bound up with many other aspects of educational organization. There are other factors, however, which are of great importance, but which are often overlooked—often with the result that what is called 'research' is in fact valueless. Some of these we have already dealt with earlier in this chapter. We turn now to others which are more specifically related to visual education. Our brief treatment will be based upon an important survey made by Carpenter in the United States, and upon experience gained by the writer in England when helping in certain research projects relating to visual aids.

One of the most interesting and extensive research projects in the field of visual education is being carried out in the U.S.A. as a joint activity of the U.S. Office of Naval Research and the School of Education of Pennsylvania State College. This work is under the direction of Professor Carpenter who heads a team of over forty investigators and covers administrative, informational, advisory, consultant and research aspects. The very complexity of the project indicates the need for large-scale and long-term planning in this field and suggests that to be effective in India research in visual education should be organized in the same way—bringing the teacher in as the indispensable field worker. Should this be done, it might well start with the preliminary six steps undertaken in the Pennsylvania project:

1. Locating, reviewing and abstracting the relevant

literature in education, psychology and audio-visual aids. It is important to do this as a first step, not merely to avoid a possible waste of time in repeating what has already been done effectively, but also in order to learn from the experience of other workers and to find to what extent research in one field may be relevant to research in another.

2. Building up a reference collection of information. Apart from pure research material there is much other information which should be available. Much of the necessary experimentation will have to be conducted in school classrooms and it is essential that projection conditions should be perfect and in no way allowed to act as an unsuspected limiting factor. Thus all concerned should be aware of optimum angles of viewing, distances of viewing and so on. Most teachers appear to give but little thought to this—chiefly because they are unaware that it is a problem. Hence the need to have information on such points readily available.

3. Formulating concepts which are relevant to visual research.

Research is a process of integrating knowledge and leading on to new forms of knowledge through experiment and criticism. This can only be done if we can start from certain acceptable premises which will allow us to postulate the hypothesis we wish to test. Too often we start off with ill-defined ideas of a nebulous nature—such as assuming that sound and colour *must* be better than silent and black-and-white films, or that pupils learn best through either visual or aural means. Instead of this we must decide exactly what we do know and what we can only surmise.

4. Reviewing and considering the methodology of mass instruction.

Over the past years we have developed certain ideas and methods of visual teaching—such as previews and follow-up work with teaching films—and one can hear many opinions put forward as to the 'best' way to present a film. It is important that our subjective opinion and experience should not allow us to develop preconceived prejudices. The best corrective is to consider the experience of other workers on as wide a scale as we can.

5. Planning the research project and designing specific experiments.

To be effective we need a comprehensive plan which can only be formulated after very careful consideration. Haphazard research, though it may appear to leave the individual's freedom untouched, is not likely to answer all the questions nor those which are of greatest urgency. Our plan must be broken into sections or units and for each of these we must plan procedure before any start is attempted. The whole emphasis of modern statistics is on the design of the experiment. If this is faulty the results will be valueless. It is through lack of attention to this point that so many of the investigations conducted by local education authorities are valueless from the research point of view—yet their results have often been made the basis of action.

6. Designing and building equipment.

Though this may appear only to be important at advanced levels of organization, as in the Pennsylvania project, it should not be overlooked in the simplest of plans. Few schools in the East have a special projection room which can be blacked out—hence the need to design and build suitable daylight projection screens. For reasons of economy it may be essential to build simple filmstrip projectors and so on. Unless all this is dealt with as a primary step any large-scale experiment may be halted by lack of suitable apparatus.

This list may appear formidable, but if worthwhile research is to be done it must be preceded by preliminaries of this kind. A vast amount of money, time and energy have been wasted in the West by attempting to conduct research in visual education without building a solid foundation of policy and possibility. Such waste must be avoided in the future, not by refraining from research, but by planning it properly. It is also essential to realize that, while there are many aspects of visual education which are universal, there are others which are specific. It is among the latter problems that India and other Eastern countries must conduct their own research programmes—for here they can least of all rely upon the results of studies made in entirely different conditions. While this may be true even of the pedagogical or instructional aspect of visual education, it is far more likely to be true in connexion with the making of films and other materials which aim at affecting attitudes—for the values, motivations and goals of behaviour in the East differ from those of the West in many ways.

After completing the preliminary basis of survey and review, it then becomes necessary to plan the details of investigation, and here too there are, as Professor Carpenter has pointed out, certain important conditions which must be fulfilled. The most important of these are mentioned below :

1. The investigation must be concerned with specific and definable variables.

Learning from visual sources is a complex process involving not only the visual materials but also the learner, his knowledge, attitudes and skills, the teacher and his skills in teaching, the social climate of the classroom and many other factors. We must know with which of these we are dealing.

2. The experimental designs must be statistically acceptable.

If experimentation is a complex situation involving many variables we must be able to control as many as possible of these and to ensure that only the ones we want to investigate are allowed to affect our results. Many variables, however, are beyond our actual control and we must therefore make use of statistical designs in order to cancel these out, as it were. Reference to this point has already been made earlier in this chapter.

3. It must be possible to produce specially prepared visual materials.

Visual materials are one of our variables—we may, for example, want to compare the effectiveness of an animated diagram film with a film of the actual thing (say the eroding action of a river on landscape) as teaching devices. We must therefore have at least two films—and we shall need to be able to make them for the job. The same condition holds in connexion with filmstrips, models and other visual materials; in fact there are few problems which can be investigated with hope of success unless we can prepare our own materials, whether these are simple or complex.

4. Special tests will be needed to measure the results of visual learning.

In experimental studies of learning we evaluate methods of teaching in terms of gains in information, increase of interest and changes of attitude. To a large extent we shall undoubtedly have to use similar methods in visual research because it may be difficult to define any other kinds of measurable outcome from the visual approach.

If this can be done we should attempt to devise special ways of testing it. Otherwise we must use tests of existing types and develop ways of distinguishing to what extent the results are due either to the visual or to other parts of the learning situation. It is to enable us to do this that the design of the experiment is important in the first place. We shall need to use special statistical procedures, such as analysis of variance, for the same purpose. It should be noted that some workers have attempted to solve this problem of methodology by a special method of scoring.

5. The results of research must be applied to the production of educational films.

Film-making, for educational purposes, has so far been a matter of happy skills and flair on the part of the individual. No one can deny that we have available some excellent teaching films which have been made in terms which are entirely subjective. This does not, however, mean that our films could not be better than they are—but this will only happen if we can obtain research results and then use them in making films of better kinds in the future. The difficulty here will be one of organization, of bringing together the research worker and the producer and then of convincing the latter that the former has something of value to contribute.

It should now be clear that effective research in the field of visual education is no light task but one requiring special and extensive provisions. These are only likely to be achieved by some kind of state planning because only the state can call upon all the facilities needed, integrate their activities and finance their work. In view of the need for research in this field it is greatly to be hoped that it will be undertaken in India on the required scale. It is also to be hoped that it will be of the required type. Research in visual education is not merely research in visual aids as a narrow and specific field. Visual aids are means to ends and the ends are something to do with children—with minds, not merely with machines. Visual research must go beyond the machine, it must spread over into psychology, sociology, pedagogy and statistics. That is why so little which is of value has been done.

Some Examples of Research in Visual Education

Although not all of it can be accepted as conclusive, the volume of research work which relates to visual education is far greater than is generally realized. To review even a small part of it would be a lengthy task with a voluminous result which cannot be handled in a small book. If, however, this book is to make a contribution to the development of visual education in India it is essential to give some examples—however briefly they are dealt with—of research in this field.

1. *The Interpretation of Static Diagrams*

Drawings and diagrams, ranging from ephemeral work on the blackboard to permanent illustrations on wall charts, and including lantern slides and filmstrips, are widely used as teaching devices. Interest in their use has recently increased very greatly but only lately has it taken the form of critical evaluation. It must be realized that the diagram is an extremely abstract form of presentation, a point often overlooked by those who think of it as a simplification. It is now believed by many psychologists that children learn first from the concrete and only lastly from the abstract. If this is so our use of diagrams may not be a simplification for the child, but a complication, because it takes him away too soon from the reality he knows. The implications of this are important to the teacher and the problems involved have become the subject of investigation at the Centre for the Study of Audio-Visual Materials in the University of Chicago. The workers at this centre initiated research work to answer two questions: (1) To what extent can children read diagrammatic material without adult help? (2) Can textbook diagrams be made more easily understandable to children by the addition of clarifying materials? They set out to answer these questions because of four conditions:

1. There are no complete investigations of the ability of children of different ages to identify pictured objects.
2. Studies of the ability to interpret graphs are few and inconclusive.
3. Data on the ability to read maps are insufficient.
4. Studies of the ability to read other diagrammatic materials are almost non-existent, largely because they are costly to produce in materials and time and because there is an *a priori* assumption that illustrative material is beneficial.

As a result of a series of reports, particularly those of Malter, our understanding of children's ability to interpret static diagrams has been greatly increased. We cannot do more here than give a brief summary of some of the findings, but it will be seen that these have many implications for the teacher.

Reading cross-sections. In very many school subjects with a structural basis we make use of cross-sections to 'explain' relationships, as for instance in zoology and botany, in geography and general science. To understand a cross-section means essentially that the pupil can transpose it back ideally to its place of origin. If this cannot be done then the section may be 'remembered', but it will not be understood. Malter tested this by drawing a series of cross-sections through a doll and a wooden stand and asking 358 pupils to show the position from which each section had come. The children came from Grades IV to VIII with age range 11 to 15. The majority of them failed to complete the task satisfactorily.

Reading 'process' or 'flow' diagrams. These are diagrams which trace a series of events or changes from start to finish. They would, for example, be used to follow the production, collection, processing, and distribution of milk from cow to consumer; or to explain the series of changes between the delivery of coal to the gas-works and the moment we light the gas fire; or, to take an Eastern case, the events which start with the picking of a coconut and finish with a coir mat. In this situation there is no problem of transposing, of re-interpretation, nothing but the following of what (to us) seems to be a straightforward sequence of events. Using a process diagram of a flour mill with 227 children aged 11 to 15, Malter found that a large majority were unable to locate the starting-point of the process, or to trace the flow through the mill, or to locate the end point of the process.

Understanding diagrams which represent cyclical actions. Diagrams of this type are widely used in teaching. Examples are those which deal with life-history studies in biology, with the nitrogen cycle and so on. Malter used standard diagrams which deal with the action of the 4-stroke internal combustion engine and the lift pump, and found that both diagrams were meaningless to most children and that few were able to read motion into them.

Results of this kind are almost startling in their implications, and become even more so when we realize that they are coupled with widespread inability to interpret effectively many other devices of diagrammatic type, such as the use of symbols. We are at once posed with the question of what can be done to increase understanding. This has also been studied by Malter in several papers, his findings being very briefly described below.

An important first step was to analyse what we usually mean by a diagram. It was decided that the typical diagram has three major components: (i) symbolic representations of the objects which enter into the primary relationships under consideration; (ii) verbal symbols on or near the central objects; (iii) non-verbal symbols.

Experiments with diagrammatic materials showed that there are two main methods by which they can be made more understandable:

1. The central objects can be related to 'referents', that is, they can be dealt with both as diagram and by other means. Thus a diagram to show the erosion of the concave curve in a winding river should be accompanied by photographs, a model, a film–and a visit to the real thing.
2. Addition of explanatory descriptions. This device, in the form of the legend to a text figure, is well known to us, but it is capable of considerable improvement by both verbal and non-verbal (symbolic) clarifying materials.

From the teacher's point of view it becomes clear that we cannot merely present a diagram and leave it at that. First we must ensure that our diagram is suitable and then we must use it properly. We must link the diagram with other kinds of approach. We must, whenever possible, use the diagram as a secondary presentation because it is an abstraction and we must use clarifying materials for orientation purposes. While we have no research yet on the point it might be noted that these findings are undoubtedly important in relation to the use of Isotype and similar abstract forms of presentation. They should also provide ideas for the film-maker who, in animated diagrams, has means of improving very greatly on the usual static diagrams.

Ability to read graphical material. As pointed out above, our knowledge of the extent to which pupils can read graphs is limited. As Malter has shown that pupils are unable to follow process diagrams it may well be that they learn less from graphs than we suspect. This point was investigated in English secondary schools with older pupils who used graphs and 'pictorial graphs' together with written material and conducted a series of experiments under carefully controlled conditions. The general conclusion was that a majority of pupils failed to understand the main principles which the visual material was supposed to show—this material, relating to the social aspects of public health, was chosen as it was unfamiliar. Such presentation can only be understood effectively by those with the intelligence and education of the good university student. Some of Vernon's own words are of extreme significance for those concerned with visual education:

'. . . we reach the general conclusion that the essential factor in understanding and remembering such material . . . is the production of a continuous and coherent argument, connecting together the isolated factual data.' This argument 'should be verbally presented, since only in words can reasons and relationships be directly stated. Also, it seems helpful to include certain explanatory inferential statements in the argument.'

Vernon's findings agree with those of Malter in showing us that our pupils get less from such visual aids as graphs than we think they do. This, however, does not mean that we should give up visual aids—but that we should make them better and use them more skilfully.

II. *Research on the use of Visual Aids in relation to Specific Subjects*

In this section it is proposed to give very brief reviews of a couple of topics in order to illustrate the kind of work which has been done and to show some of its more important results. The implications of these findings will be discussed in Section III, page 355, and we shall conclude this chapter by a brief reference to certain topics in need of investigation.

The Filmstrip in the teaching of Geometry

That geometry has a highly visual base is obvious and for that reason Johnson has studied the value of the filmstrip, as compared with more traditional teaching methods, in relation to: (i) informational learning, (ii) development of fundamental skills in geometry, (iii) ability to make application of geometrical principles, and (iv) retention of geometrical knowledge. The investigation was conducted on rigorous statistical lines and involved the conduct of 15 experiments with 27 classes consisting of experimental and control groups. It was found that for the first three criteria there were few significant differences between experimental and control groups and that these differences were in favour sometimes of one and sometimes of the other. For the fourth criterion, retention, there was a consistent significant difference in favour of the experimental group. In other words, the filmstrip had made a real improvement in retention.

Johnson makes the important observation that 'visual aids might be more effective if used to supplement normal materials by bringing unique experiences to the classroom—for example, the geometry of aviation . . . ' rather than merely repeating experiences already gained from textbooks.

Visual aids in agricultural education. Agricultural education is one of the world's important problems, as may well be seen in India and the East in general. In relation to projects in Fundamental Education and Mass Communication a great deal of work is now being done in this field and more and more attention is being given to the use of visual aids. Bentley in the U.S.A. carried out careful and elaborate experiments to test the value of visual aids in relation to three activities : home gardening, animal husbandry, and pasture production. The value of visual aids was considered with regard to four criteria : (i) informational learning ; (ii) problem solving ; (iii) ability to apply principles to new situations ; (iv) retention.

The findings of the experiment were similar to those reported by Johnson—that retention is improved but that other gains are difficult to demonstrate. Bentley makes four important observations :

1. Visual aids are better used to supplement than to repeat experiences.

2. Visual aids designed to teach new ideas or principles should be accompanied by adequate interpretation.

3. Visual aids should be critically evaluated by experimental testing before being released in final form for general use.

4. Catalogue descriptions (on which teachers have to rely) need to be greatly improved before they are of any value as a guide in the selection of films for class use.

III. *Some Problems in need of Investigation*

It is a common experience that research students seldom know the problem they want to tackle. They usually want to do research to get a specific qualification, not because they have a problem to which they seek an answer! Some, with experience of visual aids in schools, do have a problem, but it is often not very clear, so that they need help in clarification. A few bring a straightforward problem and want help with technique. Few, if any, ever have any idea as to what has already been done in this field.

The examples of research already given, although very briefly treated, will indicate the lines along which research has been done. They should suggest other topics for study. In order to show what a vast field lies awaiting exploration, it may prove useful to mention a few problems which would well repay attention. The problems mentioned are all looked at from the pedagogical or psychological angle, although one or two have a technological aspect also.

An extremely interesting and important field is concerned with the use of animation in relation to actuality. While there are various forms of animation, ranging from animated wave motion or dotted lines up to the anthropomorphic fantasies of the cartoonist, they all have something in common in which their value lies. What this is, however, is far from clear. To the film producer the devices of animation are simplifications and clarifications of what he thinks may be complex to the learner. The use of these devices at once raises many problems. It may, for example, be said that the film as a whole aims at the solution of a problem in learning, a problem which experience has shown to be difficult. To use animation devices within the film suggests that the subsidiary difficulties have been located by the method of difficulty diagnosis adopted in educational guidance. But it is doubtful if the difficulties have been located in this way. We may then be trying to simplify the wrong thing! We are working in the terms of the adult instead of the pupil. Any use of diagrams raises problems.

Diagrams are looked upon as simplifications but, in the sense that they are often used to present a percept as a concept, they may well be the reverse. The words already quoted on ability to understand simple static diagrams should make one pause. It is clear from the findings that we need to re-evaluate our diagrams. One line of investigation would be by comparing the use of animation and actuality; from this we might at least learn how to make better use of records of actuality. A second line would be to evaluate animation devices of different kinds and different degrees of complexity. Many teachers believe that the more abstract forms of presentation, such as Isotype, are meaningless to children. This may be true of some of our film work. Then again, we might explore the relative value of diagram and actuality in stimulating the pupil, in challenging him to a new point of view or a new interest. Is it possible that the diagrammatic mode makes an appeal restricted to *understanding*, while actuality may appeal to *feeling*? It would be possible to do on films what has been done with still pictures, to study the additive value of accessory devices, pointers, arrows and other signs. This field is full of problems of immediate importance and relevance. The moment one sets about planning work here the need for variant treatments shows clearly. The cost of animation is extremely high, but this should not prevent study in this field. The simplest forms of animation can be done on a very simple bench and a considerable amount of test material can be put on a short film. Moreover, here is an obvious place for using cyclic film. In the West one can also call on home production through the local Teachers' Film Group. Where motion picture cannot be used filmstrip can be tried for certain kinds of problem. The episcope too can be called on.

Views have been expressed on the relative merits of colour and black-and-white presentation. Some teachers consider that the colour version of 'Latitude and Longitude' is a better teaching aid than the black-and-white one. Here is a case where both versions are available from commercial sources. The question could be explored in other connexions–even in relation to diagrammatic material to which reference has already been made. A suitable field for this would be in connexion with morphological studies in biology and geography, though many other examples could be found.

One aspect of all morphological problems is that of stereoscopy, and many devices are used to give the illusion of three dimensions to a two-dimensional presentation. Many problems are awaiting attention here. For example, it would be possible to explore the relative effectiveness of flat block diagrams of engineering type, which present an object in plane and elevations, with the use of animated 'exploded pictures', or with a flat stereogrammatic presentation. For those who have technical facilities available one might explore the measurable gains (if any) coming from actual stereoscopic projection. This might be of interest to the school-teacher. It would certainly be of interest to those concerned with instructional training in the acquisition of manual dexterity in glass-blowing, making electric lamp filaments, the assembly or wiring of small-scale machine elements, and so on. It may be possible that training in dissection and surgery would also benefit by studies in this field. Work has been done on retention after different modes of presentation, particularly, of course, aural and visual. Here is a field for experiment, though if handled as a mere comparison of silent and sound film it is not likely to be very fruitful. The more important thing is to make studies which define the most appropriate use of sound. At present we are tending to allow commercial enterprise and technical virtuosity to produce sound films where silent ones would be as effective, so that we make reduced use of the film because of the higher cost of sound film.

An extremely interesting field for study would be in relation to the time factor in visual learning. Experimental psychologists have made use of tachoscope presentation to study threshold times in recognition of symbols and words. Film-makers are aware that this has, in some way, a significance for them. There is a good deal of discussion about the time required for recognition and reading on the screen. There is, however, another angle: the time required for learning in the sense of 'assimilation', which has been explored chiefly in connexion with the teaching of biological ideas of complex type such as evolution. This is a problem of maturation which should affect our ideas about film load and content, duration, frequency of repetition, and so on. In this form the existence of this problem has hardly been realized, yet an understanding of it is essential for the improvement of film production and usage. Another aspect of time would repay attention. How far can we use visual aids, particularly the film, in helping to develop a sense of historic time? If history has educational value it must, to some extent, rest on this, but we know very little about it. Some sentences—indeed most of our speech and reading in the last analysis—are about actions. Instead of illustrating them with static pictures we might well make use of moving picture film, and with sound film we can show the action and the words on the screen simultaneously and also let children hear the words on the sound-track. Research in this field might not only improve the teaching of reading to children, it might be of very great value in the teaching of the illiterate adult—one of the great problems in the East. In a situation of the kind suggested we are using the film to extend meaning, to enrich experience, in a given situation. This suggests investigations into the value of the film along other related lines, for example, as a means of enriching and supplementing culturally poor backgrounds. Such a problem would not be easy to handle. It would probably resolve itself into a study of the genesis, development and multiplication of interests—which, while a fascinating study, is far from easy, and which may appear to many, who fail to appreciate the real potentialities of the visual approach, to be far removed from visual aids!

From this field it is a short step to the investigation of the effect of the film on attitudes and social valuations. The entertainment film is probably the most important sociological phenomenon of the twentieth century, and for this reason alone we should be concerned with the study of the film in the moulding of attitudes. Education, however much we think of it as informational, has also its social aspect. Because its social effects on attitudes and personality are more difficult to follow, and do not become apparent until later in life, we tend to ignore them—at least we neglect them in favour of informational ends, though their social significance is obvious. One reason, of course, is that we have so little knowledge of the factors and techniques which do affect attitude. Here, then, lies a big field for investigation—indeed it may well prove to be the largest and most important of all. Like the study of interests, it will take the research worker well beyond the specific limits of visual aids into the complexity of attitude and personality measurement. The rewards of success in such work would be many and valuable. From a passive situation in which we merely study the effect of the film on attitude we might well be enabled to develop a therapeutic use of the film. If this became possible, and the success of role-playing in psychodrama suggests that it might, we could begin to treat behaviour problems in children by means of vicarious experience. Any attempt at working in this particular field would certainly become concerned with questions of film appreciation. The only way in which the educationalist can combat sociologically harmful films is by educating children to like better and more acceptable ones. Here, as in music and art, taste has to be educated. At present we are at the beginning of such work and its slow development is said to be due to the fact that suitable teaching material, particularly film extracts, is not available. Even if it were available we need to learn how to use it and to study its effects. These needs open out still wider horizons for research.

The selecting of films will always be a problem to the teacher for reasons too well known to be repeated here. The act of selecting involves appraisal and the technique of the film appraised could well be investigated, indeed the Scottish Council for Research in Education has already done some good work in this connexion. Extension is needed urgently. A host of problems will arise. Do children *see* in a film what we see? Do they interpret what they see as we do? Do they understand film conventions, such as dissolves, camera tracking, panning and so on ? Or do these devices just make difficulties greater ? Can they follow cutting ? Can they follow dialogue or commentary ? These are but a few of the questions which spring to mind on which research is needed. Before research results are available—and doubtless afterwards too—we need guidance in selecting our films, hence the importance of satisfactory appraisal.

These are but a few of the fields in which research is needed ; there are very many more. From what has been said it may be seen that in all these, while the primary problem has been cast in terms of visual education, the methods to be used involve statistical procedures and the results likely to be obtained lie in the spheres of psychology and pedagogy—as they must do if we use visual aids as means towards better education and not as ends in themselves.

XV

VISUAL AIDS IN COLLEGE AND UNIVERSITY

In a book which is primarily concerned with visual teaching methods at school levels it may appear to be out of place to refer to work of this kind at college and university level. Our teachers, however, are given a general education and trained as teachers in these institutions, and we can therefore rightly hope that to improve visual education in college and university would ultimately show an effect in the school.

What we may call the 'classical approach' to teaching has been through the spoken word. The students of Socrates literally sat at the feet of their teacher and argued—those of the East sat at the feet of their guru and listened. The Western tendency to give a more active place to the learner has a long history and probably underlies the fact that pure memorization has played a lesser part in the West than in the East. It also led to an earlier use of practical as opposed to theoretical work. It can, however, be said that in higher education as well as in schools the approach to teaching has, on the whole, been verbal rather than visual and theoretical rather than practical. The most common type of teaching in university work is through the lecture system and, particularly in the early years or at college level, the lecture is less a critical and logical exposition of principles which aim at inciting interest than a set of notes which are dictated, written down and memorized. Laboratory subjects of course call for practical work and it would be foolish to pretend that visual aids are unknown. Nevertheless it is true that visual education has made little progress in higher education. In biological science, geography, physical science and the like the microscope, the microprojector, the standard lantern and the episcope are used—but the manner of their use, in teaching as opposed to research, is confined to demonstration and confirmation. The visual approach to problem-setting situations, to orientation and to the formation of attitudes has received all too little attention. Those who have sought to develop a greater awareness of the potentialities of the visual field in higher education in the West have not found their task easy and must often have felt that they were faced not with apathy alone, but even with antipathy. The same situation appears to exist in the East. Nevertheless, despite difficulties, some progress has been made and there are signs that it will accelerate in the future. In order to give some guidance which may be of value in the East, we describe briefly some examples of what has been done in the West.

At the training college level there has been a widespread interest in visual methods and most such colleges in England have one member of the staff who specializes in visual education. Few, if any, colleges are without the various kinds of projection apparatus and they have access to commercial film libraries as well as to those of the local education authority in some cases. The contents of the Central Film Library are also available through the regional offices of the Central Office of Information. In most colleges there is a special course on visual methods (or audio-visual aids, 'new media of education', etc.). In most of these the course tends to be theoretical rather than practical, but a determined effort is now being made to train students to handle projection apparatus. In some colleges the making of filmstrips is a practical activity undertaken on the college premises. In a smaller number possession of a 16mm camera results in the making of moving pictures, though all the processing work is done by professional companies.

In university departments of education there are similar conditions, but there is a tendency to treat the subject in theoretical rather than practical terms. However in some universities, for example Manchester, there is in the Education Department a dark room with complete facilities for still photography and filmstrip making. Manchester University is equipped with all kinds of projection apparatus and also has a semi-professional projection theatre. Apart from their education departments, in many English universities visual aids (meaning mostly film and filmstrip) are used in teaching and research, and well-equipped photographic departments exist. Cambridge University was the first to set up its own University Film Council to bring together those interested in using the film in university work. From this there developed the British Universities Film Council which represents most of the universities of Great Britain. Each member university elects a representative, in this way forming an executive committee which conducts the Council's business. The aims of the Council are to bring together those interested in visual methods, to exchange information and provide an advisory service, to build up a catalogue of suitable films and to encourage every kind of relevant activity. The Council makes contact with the trade and other suitable organizations, arranges conferences, produces an Annual Film School where university staff members can learn how to make and use visual materials. The Council collaborates with the Scientific Film Association, the International Scientific Film Association, the British Film Institute and other such bodies.

A particularly interesting development exists in Melbourne University in Australia where, in addition to teaching the methods of visual education, the Visual Aids Section of the Faculty of Education also acts as a producer and makes filmstrips for educational work to the order of local schools. A visual unit is also being set up in the University of Ceylon with funds derived from the Colombo Plan Technical Assistance Bureau.

It would be of considerable value to India to encourage similar developments in universities and training colleges. Two points should be noticed. It is questionable whether any one member of the staff should be a specialist in visual aids—the aim should be to make all members of the staff interested in visual methods—and the frequent demand for high-level appointments such as a chair or readership in visual education seems to be unjustifiable in most, if not all, cases at present. The time will come when visual education is seen as a study in psycho-cultures.

Training Teachers in Visual Aids

It has become the custom in training colleges and university teacher-training departments in England to have one member of the staff who specializes in visual education—known as Lecturer in Visual Aids, Audio-Visual Aids or New Media of Instruction. This usually ensures that at least one of the staff has a thorough acquaintance with the problems and methods of visual education. Unfortunately it often also seems to have the result of giving other staff members a feeling of being relieved of any responsibility for visual methods as applied to their subject so that they often make little use of such aids and seldom explore the visual approach to their subject in detail. If it is felt that there is a need for one person to specialize in visual education, everything should be done to ensure that his knowledge and skill is made available to all others on the staff and it should be considered essential that the specialist provides some kind of training for his other colleagues.

Not only must the question of staff be settled, but so also must the question of apparatus and amenities. It is unfortunate, but nevertheless true, that one often sees visual education treated almost entirely by verbal means! No real training of teachers in visual education is possible unless the apparatus and amenities allow of work along two lines–first, the making of materials for visual teaching, and secondly, the practical training of teachers in visual teaching methods. We can take these points separately, though they are in fact interdependent.

It should be possible, in any teacher training institution, to make visual materials, at least of the simpler kinds–for example of the kinds dealt with in this book. This requires workshop and dark room facilities. The workshop need be little more than a bench with a vice and a kit of hand tools for simple woodwork and metalwork together with supplies of the kinds of material called for in making the models and apparatus referred to elsewhere. It must be admitted that a metal-working lathe and a power drill are of great value, but they are by no means essential and a great deal of work can be done without them. The dark room is essential only if a considerable amount of work is to be undertaken; for many purposes a 'dark box' will provide all that is needed. A large college, teaching many subjects, should be using visual aids on an extensive scale; many of these will be prepared photographically, hence it is desirable to have the following:

Camera. (*a*) A plate camera 4¼″ × 3¼″ (10.6 × 8.2cm) is usually used for making the negatives for lantern slides and for technical photography; or (*b*) a 35mm camera will do most of what a large camera will do and lantern slides can be made by enlargement from the small negatives.

Accessories for copying and close-up work.

Printing frames for lantern slides, contact printing of opaque photographs on paper and for making filmstrips and miniature slides.

Enlarger for making large prints from smaller negatives and for making lantern slides.

Developing tanks and dishes for plates, film and paper.

Large washing tank for washing prints, etc.

Dark room lamp with red, amber and green safelight glasses.

Bottles for storage.

Tables for working on.

Water-supply, preferably running water in a sink.

Balance, a simple student model for weighing chemicals.

Projection apparatus is obviously essential and any department which proposes to train teachers in visual aids should have available:

(i) 16*mm motion picture projector,* sound model, but silent if unavoidable.

(ii) $3\frac{1}{4}'' \times 3\frac{1}{4}''$ (8.2 × 8.2cm) *lantern slide projector.*

(iii) *Episcope.*

(iv) *Epidiascope with extra fittings.*

(v) *Filmstrip projector* (with miniature slide adapter).

(vi) *Micro-projector.*

(vii) *Sundries*: rewinder and slicer for 16mm film; spare spools; viewer–for examining filmstrips without projection.

(viii) *Screens,* folding, fixed, translucent, etc.

(ix) *Projection table,* etc.

Training should be both theoretical and practical and will require an hour a week for lectures and two hours for practical work, apart from time devoted to viewing films and other visual materials. If possible, provision should be made for extra practical work, not necessarily under supervision, for those who are particularly interested. Ideas as to the contents of a course in visual education will vary and will depend not only upon individual opinion but upon limiting factors of opportunity. As an indication of what could be attempted the following scheme is put forward. It is based upon practical experience of training teachers in service and prospective teachers and, even though far from perfect, has been found to be workable and not lacking in success. It is divided into theory and practical work. The theory was dealt with in lectures with all the students. The practical work, however, is best handled when working with comparatively small groups—say, eight at a time working in rota at different jobs. Some of the practical work may have to be handled as demonstration only, for example general photographic procedures, but as far as possible every student should get actual practice at all the different kinds of practical work involved.

Visual Aids Syllabus for Teachers in Training

Theory	*Practical Work*
(Each roman numeral represents one lecture period)	
I. The Range and Use of Visual Aids	
1. Episcope, diascope and epidiascope.	Handling each type. Uses of each. Design and making of simple episcope and diascope.

Theory	*Practical Work*
2. Filmstrip projector and the use of filmstrips.	Handling. Use of strip and slides. Making simple strip projector.
3. Micro-projector.	Handling. Use in demonstration and drawing. Projection with the microscope. Making a simple micro-projector.
4. Silent motion picture projection.	Handling apparatus. Screen types. Projection conditions. Daylight projection. Film splicing.
5, 6. Sound projection.	Handling. Faults. Maintenance. General points in illumination. Battery and mains power. Transformers and resistances. Wiring. Distribution Board. Storage of film and filmstrips.
7, 8, 9. Pictorial materials.	Use of blackboard. Stereograms. Enlargement. Making wall-charts. Indexing and storage, etc.
10, 11, 12. Models.	Cardboard and plywood models. Clay and plaster-of-Paris casting, relief maps, etc. Functional models. Take-apart models. Models for the episcope.

Theory	*Practical Work*
II. Psychological Aspects of Visual Education	
13. Visual perception and its relation to learning.	Simple experiments on visual perception.
14. The illusion of reality in the film and how it is obtained.	Examination and analysis of films.
15. Problems in learning which can be aided by visual means.	Examination of specially prepared materials.
16. The visual approach to abstract ideas.	Screening of suitable film and filmstrip.
	Continuation of practical work in Section I
III. Pedagogical Aspects of Visual Education	
17. Use of visual material in the classroom, integration with lesson, etc.	Planning and preparation of visual presentation in relation to special topics. Discussion.
18. Preview, follow-up and problem-setting.	Above continued.
19. Review of research on effectiveness of visual presentation.	" "
20. The film in child life today.	Screening and discussion of entertainment films.
21. The teaching of film appreciation.	Screening and discussion of films.
22. The museum and its place in education.	Visit to local museum.

Theory	*Practical Work*
23. Film and radio in education.	Planning to give visual background to broadcast lesson.
IV. Practical Teaching Procedures	
24. Organizing a school visual service.	Use of catalogues, film reviews, film libraries, etc. Ordering, checking and return of hired materials. Hints on methods.
25. Building a school collection of visual materials.	Demonstrations of mounting, filing, exhibiting, etc. Preparation of a small special collection by each student.
26. Arrangement of seating, position of apparatus, wiring precautions.	Try out with class : compare screen light intensity, distortion, etc. Experiments on 'throw' and image size.
27. Visual units and relation with activity work.	Planning visual units and project studies.
28. Visualizing the curriculum.	Selecting and preparing materials for use with the general curriculum.
V. Simple Photographic Methods	
29. The elementary basis of photography.	Demonstration of methods. Making a lantern slide, developing, printing.
30. Apparatus and methods.	Demonstration of how to make a 'dark box' and accessories,

Theory	*Practical Work*
31. Photography and the filmstrip.	Making original drawings, etc. Photography out-of-doors. Close-up work with supplementary lenses.
32. Printing the filmstrip.	Materials and method. Ways of printing. Making a printing box for strips.
33. Simple photo-micrography.	Photo-micrographs with the enlarger. Using camera and microscope.

It will be seen that in drawing up this syllabus an attempt has been made to give a wide interpretation to visual education and to strike a balance between the practical and theoretical aspects of the problem. In many cases the training of teachers in visual aids is looked at only in practical terms so that, although competent in the handling of projection apparatus and in photographic procedures, the students fail to achieve even an elementary understanding of how to use visual materials in teaching and even less of why they should be used in particular ways. It is almost impossible to over-emphasize the importance of the need to think of visual aids as means rather than ends. However great the appeal of the 'gadget', it must never detract too much from the teacher's concern with its effect upon the mind of the pupil. To acquire the necessary skill to handle projection apparatus is fairly simple and in England it is done not only by men and women teachers but also by boys and girls in schools. Photography is simple and the production of a filmstrip, from the mechanical aspect, not difficult. The making of apparatus does perhaps call for some mechanical and constructional aptitude, but even here much can be done with simple tools and little skill.

If visual education is to progress in the schools, it is necessary not only to train teachers in their college days but also to do something for them afterwards. And it is still more urgent to do something to help those who will never get to college at all and who form a very great proportion of the teachers in India and Ceylon.

The provision of training courses in visual aids for teachers in service could most effectively be done by the appropriate education authority, and it is of interest to note that in some cases work has been started in this field. Thus in some Indian states and in Ceylon also there is a visual education service with an inspector or other official specializing in this work. Film libraries have also been formed by both official and commercial enterprise. In England, despite the interest and support of the Ministry of Education and the local education authorities, there has yet been room for independent action organized by the teachers themselves. There is need and opportunity for this also in India and Ceylon. However, whether work in the field of in-service teacher training is sponsored officially or by teachers themselves is a matter of somewhat academic interest. From the more practical point of view we can say that it cannot be effective unless the central authority and the teachers work in collaboration and that, irrespective of who sponsors it, the scheme must cover six needs:

1. It must ultimately aim at making it possible for a school to have visual materials available for use in connexion with the curriculum as required. No mobile service can make it possible for visual methods to be used in the most effective way.

2. It must aim at providing a centralized loan service for films and other materials which are too costly to be owned by individual schools—and this loan service must be more than a film library, it must deal widely with visual aids.
3. Whatever its degree of centralization in terms of executive control, it must have a basic framework of local organization which gives to teachers a place of authority and responsibility for helping in the furthering of visual education.
4. It must be practical in the sense that teachers are trained to make simple visual materials and simple apparatus as well as to handle projection apparatus ; these things cannot be done merely by talking.
5. It must not neglect the theoretical aspects of using visual aids in the classroom.
6. It must keep teachers informed of additions and extensions to its services and of the new developments which are taking place in visual education in theoretical and practical ways.

Those who are concerned with teaching the use of visual materials and methods, whether it is to students in training or to teachers in the schools, must be competent and experienced in visual education and they must have the necessary materials and apparatus at their disposal. Moreover they must suit their demonstrations to the conditions in the schools. It is of little use for teachers to learn how to use a sound projector if neither finances nor a projector are available in their own school.

In all work of this kind those who are responsible must be aware of the possibilities and limitations in the schools. They must know what materials are available locally and how, if necessary, to adapt these to their purpose. They must offer ideas and instructions within the bounds of what is possible. In organizing work of this kind the officer in charge should study the limiting factors and plan ways of overcoming them. He could well have a series of visual aids, such as materials, models, filmstrips and films which demonstrate the right use of the visual approach—and these 'visual aids to visual education' must be specially prepared for the specific job. This can be undertaken by making a set of photographs, by slides, filmstrip or motion picture film. One or more filmstrips on visual methods will be found valuable. Some are already available but they have been made in a Western setting and, though the major principles will be constant, they will not be directly applicable to conditions in the East.

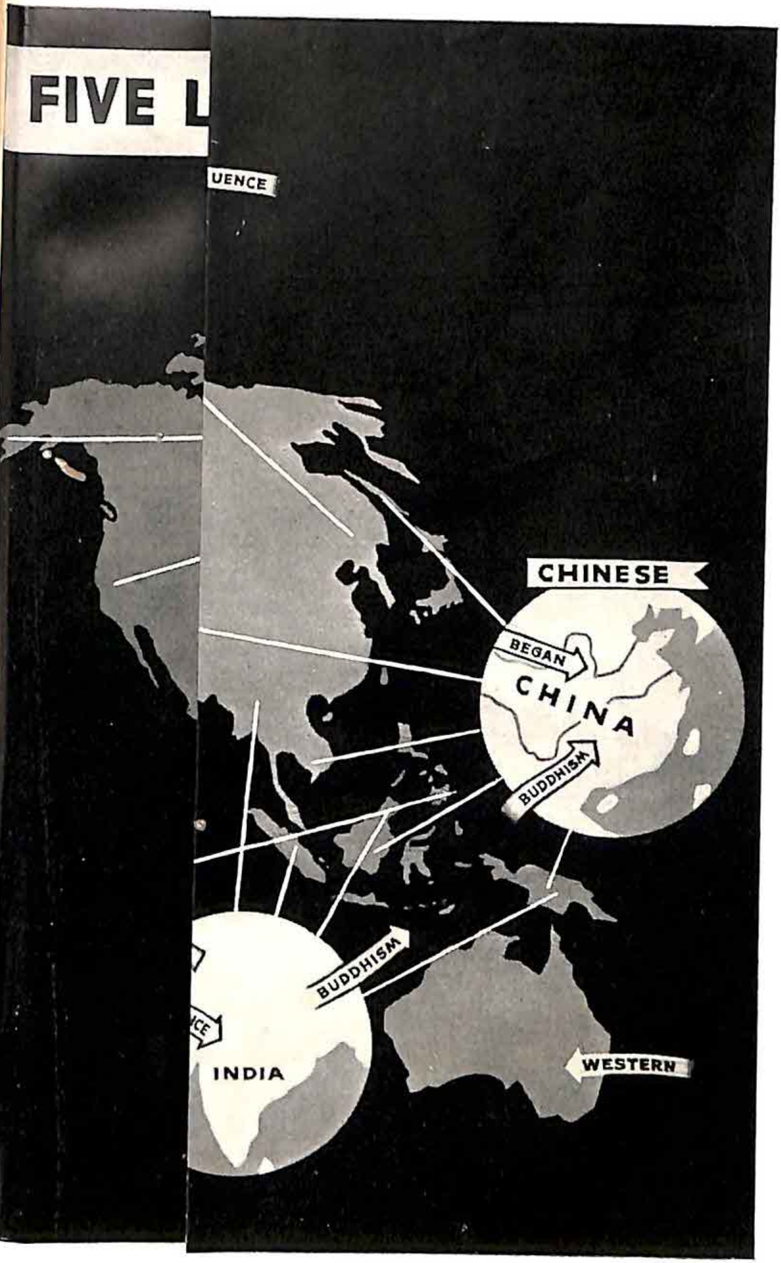
This point must not be overlooked because we shall otherwise tend to arouse wants before there is any hope of fulfilling them. The task of those whose duty it is to encourage the use of visual aids must be that of determining exactly what is needed and how it can be obtained under various limiting conditions which must be fully understood. Two examples will make this point clear. While the lack of electric current in many areas is seen as a challenge to the development of kerosene projectors, it should also be thought of in relation to the problems of projection. The vast majority of schools have no blackout and the frame buildings with half-walls make normal blackout procedures impossible to apply. Here is the point for attention to daylight projection with a translucent screen—personal experience has made it clear to the writer that the possibilities of this device are practically unknown, even in training colleges, in the East. Nor has the great advantage of rear projection with the episcope been appreciated, though it is simple and extremely effective. A second example is concerned with wall pictures. The majority of these are of Western origin and, while their content may be suitable, their use of English is less often so. To the obvious suggestion that the teacher could make his own, the reply often is that he lacks the necessary skill. Very few teachers have realized this—and still fewer attempt to put the realization into action—that pictorial and printed materials can be obtained from Press cuttings, pictorial magazines, etc. and, by the 'scissors and paste' method, built into pictorial presentations of ideas. Moreover, this is an exercise in which pupils can participate, to the advantage of the supply of visual aids materials, and to their own advantage in terms of knowledge and interest. Some examples of posters made in this way are shown in plates 1 and 2.

Mobile Vans

In every region where schools are scattered and transport services not highly developed it is found difficult to organize training courses of any kind. This is particularly true of visual aids, for which considerable amounts of apparatus and materials are required if the training is to be anything more than a 'film show'—and at present this is often all that it is. One answer to this situation, perhaps the best answer, is the use of mobile vans. These should not merely be fitted with a projector but should be travelling demonstrations of visual aids as a whole, staffed not merely by a technician but also by a teacher who is experienced and competent at visual aids work. Such a service could undertake three kinds of activity:

1. Screening of educational films both for schools and in relation to rural adult education.

2. Training teachers and all concerned with rural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reconstruction or fundamental education in the theory of visual methods of teaching.

3. Providing practical demonstrations and training in the making of simple visual aids apparatus and materials.

A programme of this kind would prove of immense value for every aspect of education, both school and adult, and could be made to link with, and add to, the value of the field work of those concerned with health, agriculture and the like. Mobile vans have been extensively used as a means of screening films over wide areas and we have accumulated more and more knowledge about their use in the manner proposed above—always to the effect that they provide an effective and perhaps the only way of initiating visual education over a big area.

The organization of a mobile service raises a number of questions, of which that of cost will always be a limiting factor, though we cannot enter into it here. Some other points which should be considered are discussed below.

To reduce costs the vans should do as big a job as possible. Thus each van should be fitted so that the following materials, apparatus and services can be available.

School broadcasts, by carrying a standard receiver of school type, sets of recorded school broadcasts, written material to illustrate broadcasts, etc. The possession of an electronic tape recorder or disc recorder is valuable both for collecting field material to be used in later broadcasts and for demonstrating the making and using of broadcasts.

Gramophones, a simple instrument and a supply of records can be used to demonstrate the use of the gramophone in school music, singing and language teaching.

16*mm motion picture projection,* both sound and silent, and so arranged as to allow for projection in the school or in the van with a rear projection screen. Supply of films.

Filmstrip projector and supply of filmstrips.

Episcope, diascope or epidiascope to show principles and methods of projection, together with supply of suitable materials.

Micro-projector to demonstrate use in biology and science.

Screens, different types, method of making and using.

Stands for projectors, to show design and method of making.

Apparatus to show different methods of illumination, electric current, battery, and kerosene.

Making and maintenance of audio-visual apparatus—by carrying apparatus of simple design which can be made in a school workshop together with instructional notes, diagrams and sets of parts to show how each apparatus is made.

Work-bench and hand tools are essential if the service is to offer all that teachers need.

Operator and a teacher who has been specially trained and seconded for work of this kind.

It may appear as if this list contains too much, but experience has shown that it is possible to deal with all this and that such a van can make a real contribution to the development of visual education. Nor should it be overlooked that the van can also be used as the basis of routine inspection of apparatus, providing a maintenance service and representing radio and museum work in the schools.

It may be well to point out that two developments are highly desirable if visual aids are to make a maximum contribution to college and university work. One of these is the steady production of films and filmstrips specially suited to use and needs in India. This raises the question of finance, but in seeking economy it should be realized that Indian films for Indian children are a far better investment than those made in a Western culture pattern—however skilled the production, adaptation and re-editing of the commentary. Films are expensive, but the education of the country's children is a responsible task in which all forms of wise expenditure are justifiable. Moreover, as has been pointed out elsewhere, one does not always need long 'talkies'; many of the most effective teaching films are short silent films—some as short as two minutes.

The second point concerns the need for the integration of activities, pooling of knowledge and resources and the dissemination of new ideas—which ought to be achieved without the multiplication of organizations which exist in England. There are found three central agencies all concerned with the educational use of visual aids—the Ministry of Education, the National Committee for Visual Aids in Education and the Foundation for Visual Aids. The local education authorities, in all the more important areas, also work in this field, and there is also the Federation of Teachers' Film Groups. It should be possible and would be profitable to have a centralized committee which could undertake all that is needed in this field. This Visual or Audio-Visual Committee should have on it representatives of the central education authorities, state education departments, training colleges, universities, teachers in schools and the commercial producers. Behind it should lie the widespread network of these different agencies working locally, and it should have power to form sub-committees for special jobs, to co-opt to these sub-committees and to call in and consult

reconstruction or fundamental education in the theory of visual methods of teaching.

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Gramophones, a simple instrument and a supply of records can be used to demonstrate the use of the gramophone in school music, singing and language teaching.

16*mm motion picture projection,* both sound and silent, experts. Such a device should result in co-operation instead of the strained relations which come into being when several agencies are each trying to do the same job.

If the training of teachers in service or of those in training colleges and universities is to be effective, it is necessary to consider the need for visual aids made for training in visual methods of education. It has been the writer's experience that even in England, where the organization of visual education has shown signs of success, there are many teachers who have no knowledge, or only the barest knowledge, of the mechanisms and materials of visual education. There are even more who use these methods without a proper understanding of their apparatus and materials—and still more who have failed to seek an understanding of the theory underlying the visual approach. It may well be said, in justification of the last point, that one cannot understand what does not exist—and no coherent theory does exist as yet. Despite this it is possible to make some kind of theory as a basis for visual methods. Moreover, it is essential to do so in order to obtain any real gains from using even the simplest of visual aids.

It must therefore be accepted as an initial point in a training programme in visual education that we should produce suitable visual materials for this purpose. Reference has already been made to the existence of filmstrips which demonstrate the principles of projection, for example. There are also films in this field, on the use of the microscope for instance. Such an idea could well be exploited in India by making a series of filmstrips and moving picture films which deal with the practice of visual education under three main headings:

1. *The mechanisms and materials of visual education.*

This section would deal with such topics as : (i) Episcope, diascope, epidiascope. (ii) Filmstrip projector. (iii) Moving picture projectors. (iv) Screens and the conditions of projection. (v) Non-projected materials, wall charts, models, etc.

2. *Using visual aids in teaching.* Here we could work along such lines as : (i) Organizing visual aids in the schools. (ii) Points on storage and filing. (iii) Planning the lessons and integrating visual materials with them. (iv) The preview ; teaching with the film, etc. ; follow-up work. (v) Use of visual materials by pupils. (vi) Preparation of visual materials by pupils.

3. *The theory of the visual approach.* Some suggestions to explore here are : (i) Problems and difficulties which can be tackled visually. (ii) The special attributes of visual materials. (iii) The devices of the producer. (iv) The psychology of visual learning. (v) The visual approach to attitudes and sentiments.

Such a series would be of enormous value and would not merely expedite a training programme but also add very greatly to its value. The series could probably be produced to a standard pattern of one sound film of 400 feet (120 metres) and filmstrips for each section–a total of three films and six filmstrips. If it were felt that this was too ambitious it might be possible to make one film and three filmstrips. In this case the strips could be used, in conjunction with explanatory notes, to deal with all the static materials and with everything except the film itself. For this we should need a special film on 'The Film as an Aid in Teaching' which would deal not with the mechanical aspects, but with questions of what the film can do for the teacher–or, more important, for the pupil.

In the following tabulation will be found a first draft for the content of such a film, which could very largely consist of shots cut from existing films—in other words it could be made by editing library materials and would not call for very much new production.

Draft script for a film for teachers; purpose of film: to indicate to teachers the educational value of the film as a medium for teaching and learning. (This draft would need to be recast as a script for shooting by the film-maker.)

Commentary—brief suggestions for line of approach, to be written up as a full commentary.	*Visuals*—suggested topics and sources.
Film and life	
Films are part of the background of modern life and play a considerable part in the life of children, especially in towns.	Children's cinema club: going in—watching film—coming out, etc.
The film has become an important agent in giving a pattern to living—it acts as a sociological determinant.	Film shots: family—'It's Friday night—what picture shall we see?' Cinema queues waiting.
Like all dynamic environmental factors the film is a potent agent in bringing about changes of behaviour.	Children collecting pictures of film-stars. Boys 'playing out' a thriller seen on the screen. Adolescent girls following screen hair-styles and dress.
Education—general	
Education is a process of	Civics group at work in

directing development towards social ends.	classroom, on visit to town hall, at play in the school playground.
Educators cannot afford to neglect so potent an instrument.	Teaching with a civics film.
The attributes of the film	
What are the potentialities of the film?	Child audience watching a film.
Communal viewing—sense of reality.	Book pictures looked at by one child—but seen by many on the screen.
Emotional appeal, self projection and identification.	Audience reaction among children—pleasure, excitement, fear, horror.
Films as a background—orientation to give pupil by vicarious means what the teacher has by virtue of age and maturity.	Chemical demonstration in laboratory and the real thing in the factory. Shots from a general culture film.
Using the film	
Direct teaching with film in class.	Class watching daylight projection of moving diagram film.
Physical conditions of seeing the film.	Audience not too near, nor too far—nor too wide an angle. Shots of different screens to show effect of wide viewing angle.
What the film can do	
The film increases understanding.	Classroom scene: reading aloud. 'I wonder what

	it looks like '—teacher's drawing and small text figures.
The world in the classroom.	Contrast with film, many views of same thing—sense of reality.
Control of space.	Tropics to pole—geographical scenes.
Control of scale.	Cine-photo-micrography—amoeba. Cine-telephotography—mountains.
Control of time.	Shots from natural history film. Speeded movement: plant growth. Slowed movement: tongue of frog.
Relational movements.	Simultaneous movements of small machine parts—gearing—fuel point injector, etc.
Analysis and analogy.	Muscles as levers. Mountain folding—in cloth on table-top ('fade in' from actuality to diagram).
Similarities and differences.	Propeller and fish-tail. Glider and fruit bat. Aeroplane and bird's wing.
Moving diagrams and animation.	Moving arrows, growing line on a graph, track of passage over globe or map.

Value of building up a complex diagram on the screen while the class watches–gives time for comprehension.	Eroding action of pebbles in stream ('fade in' from reality to moving diagram). Completion of a complex animated diagram by gradual additions.
Sound recording as a natural effect.	Animal noises. Musical instruments.
Descriptive commentary.	Factual statements about a simple thing or situation –class watching and listening.
Evocative commentary.	Class listening with obvious excitement to commentary on exciting event seen on the screen.
Sound in language teaching.	Language class at work– 'How to do it' sequence. Tongue movements.
The human touch : the man who 'knows how to do it'–the man who 'has been there'.	The craftsman at work– 'How to do it' sequence. The scientist, explorer, etc. telling of their work. The baker, the postman, etc. and their jobs.
The cine-film in recording and research.	Slow-motion analysis of movement, e.g. in jumping, pole vault, machinery. Camera recording experiments. Micro-film and micro-file.

The producer's tricks

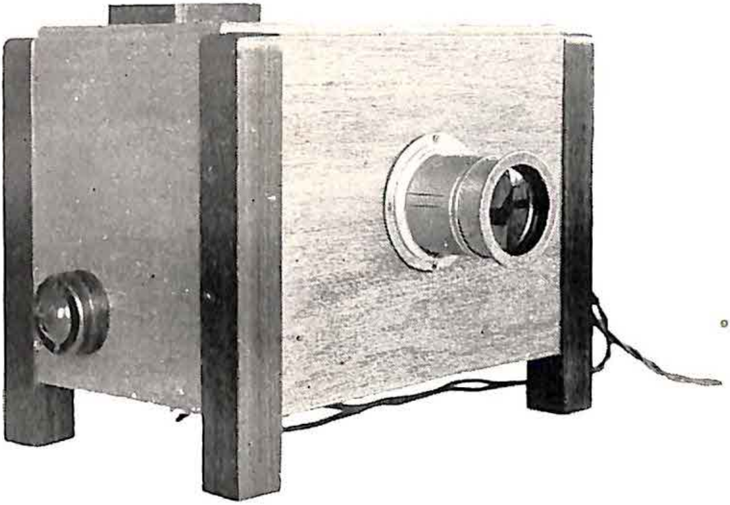
How does the producer achieve reality? Camera tricks which he can use and other devices.	New angles of view. Perspective control. Long, medium and close-ups. Tracking and panning. Cutting for smooth continuity or hard contrast. Fading, lap dissolves, etc. Suggesting the passage of time.

Producer and teacher

Films must be made for use in school—co-operation of experts, especially teacher and producer.	Talking over plans. Shooting with teacher as adviser. Editing with teacher as adviser. Previews and try-outs.

Types of film

'This is a sound film . . .'	Shots from 'Instruments of the Orchestra'.
. . . but the silent film has a place—a big place—in education. . . .'	Classroom scenes—two teachers using silent film—different approach, different commentary.
The loop film.	Loop absorber in action showing cyclic action on screen.



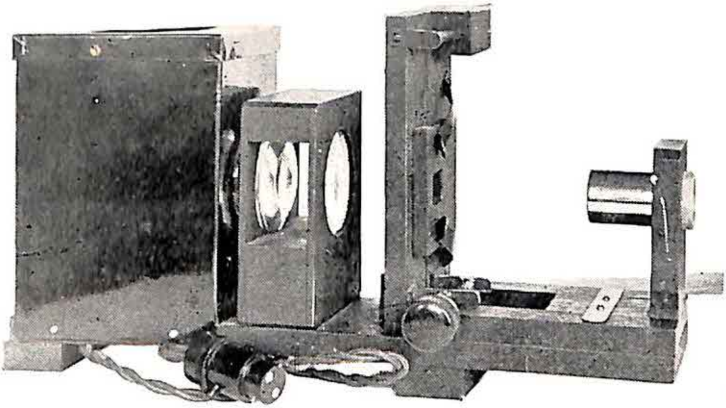


PLATE III

Home-made apparatus built by teachers.
Above—episcope ; below—filmstrips projector.

Finale

Film like a modern power tool . . . can do more and better work if properly used . . . but can *never* replace the teacher, can never do as much as the teacher.	Chemical demonstration in —friendly relations, questions and answers—continued out of school: teacher visiting homes and talking to parents and children.

This draft for a script is very much of a rough draft and it would need to be re-scripted by an expert. It is based on material which the writer prepared while a member of the Teacher Training Panel of the National Committee for Visual Aids in Education in England. This body planned to produce a set of visual aids for training teachers in the use of visual aids. The idea is sound and it would require only minor adaptation to produce something which would be of very great value in India and other countries of the East where visual education is not yet well developed.

XVI

THE VISUAL APPROACH TO THE TEACHING OF ADULTS

ADULT EDUCATION in the West has a long history throughout which visual media have played an important part. In its earliest days the 'magic lantern lecture' was a means not merely of education but of entertainment and social experience. In the twentieth century, as the movement for adult education grew, visual media were more and more used. The last ten years or so have seen an even more rapid extension of the use of visual aids and the production of materials specially made for this type of work—particularly of documentary films and filmstrips.

In the East, while the position may be somewhat similar in the large cities where the population is westernized, it is very different in the rural areas. Most Western adults are literate, they live in a highly organized society with complex provision for social living and they have a not inconsiderable general educational groundwork. In the East many adults are illiterate, they live in simpler societies with few administrative provisions and few have even the most elementary general education. The task of adult education in the East, then, is not to add to an existing framework, but to build up that framework from the base. Moreover, because of the lack of social provision, many adults have to be educated not merely in terms of skills but of the whole of living. Hence adult education has very properly been termed Fundamental Education—so far as backward communities are concerned.

Fundamental Education is education in the art of living.

It is a re-orientation of hopes, a developing of attitudes and a founding of faith—as well as a training in skills and knowledge. And, because of its nature, it is well suited to a visual approach. The man who has been taught about pure-line seed or paddy transplanting will probably not alter his habits. Knowledge alone, even among the highly sophisticated, is seldom the stimulus to action. Action, altering one's whole way of living, depends upon attitudes. Working against the clock, sticking to a time-table, conscientiously adhering to an exacting and laborious technique, thinking ahead on a long-term programme—all these depend on new attitudes and a new faith. Attitudes and faith are affairs of emotion and experience, as well as knowledge.

As we have already seen, the visual approach has much to offer in relation to attitude formation and emotional experience. The illusion of reality, our readiness to identify ourselves with the characters and situations on the screen and the dramatic effects which can be achieved by lighting and cutting are all factors in stirring us to emotional response. The meaning of this, in relation to Fundamental Education, can perhaps be best seen in such films as : *World of Plenty, The Tree of Wealth, The Plow that Broke the Plains, T.V.A.* and *Up from Poverty*.

Those who work in the field of Fundamental Education need to know not merely the potentialities of the visual medium, but the limitations of the field in which they work.

These limitations are of two kinds. On the one hand we have those which are physical—the lack of electric current from mains supplies, the lack of halls, the lack of blackout and the like. They are shared by the majority of schools in India and Ceylon. And they should be a challenge to action rather than an obstruction to progress, The whole purpose of this book has been to suggest ways of overcoming difficulties of this kind—so that those who want to use visual methods can be independent of them. In the vast majority of cases the answer will be makeshift methods—kerosene illumination, car batteries, home-made apparatus, daylight projection, models from scrap, home-made filmstrips and so on. A few, perhaps, may be fortunate and have a mobile visual aids van—but for most it will be a case of 'make do and mend'.

Our other type of limitation is on the human side—and is really a potentiality. The cinema is an accepted part of Western culture and we accept and understand the conventions in which it works. This is not so for the unsophisticated rural people of many parts of the East. Where we see a meaningful and logical story they may see no more than a jumble of meaningless images. This is the extreme, but to a lesser degree it extends a long way in the culture patterns of those for whom we are trying to cater. It is a fatal mistake—made far too often—to use films with a Western setting for people who live an utterly different life. When we make films for them we have to be more direct, to take fewer liberties in our control of time, space and speed, and we must be simpler in our treatment. This is not a suggestion that the rural dweller of underdeveloped areas is less clever than those who live in westernized society. It is merely a statement that though we have spent fifty years in acquiring our present standards of cinematic technique, we do not have to use our most advanced techniques among simple societies.

The question of how to use visual methods in Fundamental Education cannot be answered with any sense of adequacy because our knowledge is so slight that we are driven to conjecture—despite the existence of a number of pamphlets and articles (see bibliography). Film discussion groups have been used with success in cases where the film was appropriate and where the group leader not only knew the film but also understood his group and was competent in leading discussions. In general the atmosphere should be informal and there should be a readiness to let the audience guide what happens, rather than follow a groove dictated by the film. Filmstrips can make a big contribution and act as a basis of discussion too—and the group leader can make his own. There should be willingness to let the audience dictate the speed of progress, and the visual material has to be shown several times before it makes its most useful contribution.

There is a very great need for short films and short filmstrips for this kind of work—dealing with one point at a time. Some of these could be made by the amateur. Another need, again one which the amateur might meet, is for material organized in logical units—Visual Units. The haphazard programme of 'magazine' type has little to commend it—and a good deal of work with mobile vans is little more than haphazard. The Visual Unit approach has another value: it is many-sided, it presents the same facts in several ways, thus perhaps meeting the needs of those who learn differently or at different speeds. This point might be illustrated by such topics as digging a well, making a smokeless fireplace or making a fly-proof food store. All could be done on moving picture film, but though it might contribute much in terms of motivation—getting the audience to want to do these things—it may leave gaps. The film moves rather quickly and the camera angle does not always disclose the details of a process. Here is a place for still photography, showing the same process and materials seen from different positions—and more slowly—with plenty of time to look at them. These still pictures could be represented in two ways, on a filmstrip and as a set of enlargements. The former allow for communal viewing, the latter for individual inspection at leisure. We can go further—say in terms of a model, or a series of models. One could show the raw materials or the untouched situation; next the materials cut and finished to shape; then one or two stages to show the sequence of assembly or completion; finally the finished job. Still another approach is open to us, with a literate people: a set of notes, dealing with quantities and sizes of raw materials, with comments on procedure and order and an estimate of time and costs.

Another use of visual aids—especially the application of photography—in Fundamental Education, is in terms of recording. A Fundamental Education team works in one place but hopes that its influence will spread outwards. In rural areas people do not always travel far, so that some, not far from a centre, though they may hear of its work may never see it. To be able to substantiate the story of what is going on with visual evidence of its occurrence is important. Such a record is of course also useful to workers on the project as a means of evaluation.

Just as stress has been laid on the need to get the learners in school concerned with the making of visual aids, so should the same be stressed in relation to adult learners. Fundamental and general adult education will be carried out in a less formal setting than the schoolroom. This should make it more easy for participation to take place. Many who practise folk arts and crafts are skilled in detailed work and could be useful in model-making and even in graphic arts. Apart from such directly practical work there should also be opportunity for criticism and evaluation of production plans. Long before a filmstrip is made its content can be tried out with a typical audience. Long before actual production is started, while planning and the contents are still ideas and words rather than pictures, we should be concerned with evaluation. We must be critical of our plans and, when they are finally put into production, we may find the effort justified in two ways. We shall have made a better film, and we shall be able to use it more effectively because we know its content and purpose intimately.

Fundamental Education activities will usually be in the hands of the Ministry of Education so that integration of the visual services of different kinds should be effective. There is need, however, of wider integration. Many ministerial departments consider it to be their duty to participate in field work of educational type. Thus agriculture, public health, social service and rural development departments may all be working in the same area. The need for integration at the central level is obvious—and a similar need for integration in the field also exists. The existence of several bodies concerned with what is educational work not only raises the question of integration in administrative terms, it is equally necessary in terms of production. Many visual aids products coming from, or sponsored by, government departments show little evidence of an understanding of the problems of teaching. The making of such products, films in particular, should not be left to those whose only qualifications are enthusiasm and a knowledge of film production. The teacher's angle must be represented from the first.

It is not possible to enter into details of production or needs except very briefly—but a few comments might well be made. The first and basic point is that the outlines of the complete production plan should be drawn up, by co-operative discussion, before production work is started. The real way to start planning is not by asking, 'What films, etc. shall we make?' but 'What are our greatest problems in fundamental education?' and, 'How can we use visual methods in seeking to solve them?' It is important that we ask, and attempt to answer, these questions in terms of specific social situations. Human values vary, motivation varies, in fact societies show remarkably little similarity. To attempt to make a film with a universal appeal is foolish from the start–yet the attempt is often made. The only reason that we are ready to think that such a film has been successful is that we have failed to make any critical evaluation of its results.

It should be clear that a considerable degree of knowledge of the social conditions in which the film, or other visual aid, is to be used is essential. This does not of necessity mean that only a local person can guide its production. He may know little of the problems of cinematic work and may never have seen his own social background in a critical way. Unless there is something of social psychology and anthropology in the approach of the film it may fall very far short of our expectations.

It would be presumptuous for one who is a foreigner with only a few years' residential knowledge of the East to attempt to define what topics should be dealt with visually. At the same time, there is a measure of agreement as to what are some of the major problems, and it will not be out of place to mention a few of these. From some acquaintance with village life in Ceylon and India it would appear that the chief subjects for which visual aids of different kinds could be used are the following:

House structure and equipment. Such points as general designs, ventilation, drainage, kitchens, smokeless fireplaces, latrines and water-closets all need attention if the hygienic level is to be raised.

Food preparation, etc. Attention should be given to dietetics, food preparation, the use of varieties of food, cleanliness, storage, the hygiene of water, etc.

Food growing. Apart from large-scale agricultural work there is a place for attention to what we might call 'cottage gardening'. Even under conditions of extreme fertility people starve, or are at least under-nourished, because they have no good techniques of small-scale gardening.

Community services. The making of wells, bathing places, village ponds, lavatories, and the like—with an emphasis on the avoidance of pollution.

Child care. There is a vast field for attention here in relation to the hygiene and psychology of child rearing practices.

General health. The whole subject of infection and asepsis needs attention. Health hints, simple first-aid and common illness can be dealt with visually. Special attention should be given to malaria, hook-worm, skin infections and the like.

XVII

A NOTE ON THE INTEGRATION OF VISUAL AND OTHER SERVICES

EDUCATION is not a process confined to the classroom. It is coexistent with the whole of life and, during schooldays, must carry over into other aspects of child experience. Hence, we must make a brief reference to one or two other points.

The library, whether it be the local public library or the school library, is an important agent in the process of education—though it has a long way to go in the East yet. In building up a visual aids service the part the library can play should not be overlooked. It should make available collections of pictures and well illustrated books and there should be a closer connexion between these and the growing visual aid materials of the school. If one of the functions of visual education is to widen interests we must ensure that some steps are taken to meet these interests as they develop. We ought also to try to increase interest in the visual approach by making available in the library the teaching notes which usually accompany films and filmstrips. There is no reason why the library should not make use of visual aids both for its own purposes and to back up what visual education is trying to do. Thus the showing of a film on, say, the Laplanders could be the occasion of a special library exhibition of books, pictures, maps and even models related to this topic.

Nor should we forget that the library, if it is to make the maximum contribution to school life, should have a section for teachers—which should include books on visual aids.

From this short note on the library we turn to the museum. This is obviously a special kind of visual aid —and one which has received all too little attention in the East. Even where the most magnificent museum exists there is still room for the school museum, however humble it may be—providing that it has been built up with the co-operation of pupils and is not a mere mausoleum of unwanted relics.

Taking first the professional museum we can at once say that it offers great opportunities to the teacher—which are all too seldom taken. There is one golden rule about using museums : go to them with a purpose, not on an aimless visit. The purpose should be simple and clear and the work to be done planned in advance. The teacher should know the museum before the visit is paid and the co-operation of the museum staff should be sought. They are always competent in their various fields of study and usually only too ready to help others to make the best of their collections.

In the larger Western museums there are usually not only guide-lecturers but also members of the staff who are particularly concerned with children's museum interests. Some of these are often teachers who have been selected and trained for this particular work.

With a problem in mind, knowing what is available, and with the co-operation of the museum staff, any teacher and his pupils should be able to derive a lot from such visits. Each pupil should have a specific job to do and be suitably equipped with notebook and pencil. The visit should not merely be a case of looking at and drawing things. There should be discussion, comparison, talks to the museum staff—everything which can give wider meaning to the experience of seeing. In some museums there is an admirable system whereby there are special 'teaching sets' of the more common things which pupils can handle for themselves.

Unfortunately museums are often either non-existent or too far away for the schools to make use of them. This situation can be tackled in two ways at the professional level. One is the use of circulating collections which are distributed to schools on loan from a museum. This method has proved its worth in many places in the West and it should be of equal value in the East. Collections for circulation must be carefully selected and pruned of all that is not essential—this is not a disadvantage but rather the reverse. Each collection (which needs to be packed in a strong but easily handled container) must be built round a central topic which must be related to the work of the school. Here there is need for carefully integrated planning in which teachers and museum workers are both concerned.

The use of mobile museum vans is a fairly new feature which has shown its value in a number of places. Apart from the technical and administrative problems involved, the educational aspects require careful attention. It is doubtless tempting to try to use a mobile museum to take a complete miniature museum round the country—but it may be far more effective to give fuller treatment to only one or two topics chosen because of their interest or special importance.

So far as the educational use of the museum is concerned, it is in the formation of a school museum that the teacher has the greatest degree of control of the situation. Every school ought to have a museum, because it offers an outlet for the collecting interests of children and because it offers an opportunity for democratic social relationships between teachers and pupils. In setting out to construct a museum, however, it is essential to be clear about the function of the museum—it is a teaching aid, an avenue to direct experience, and not merely a collection of objects for passive observation.

In view of limitations of space, money and time severe control must be effected over the plans, or else childish enthusiasm may soon convert a good idea into a rubbish dump. It is wise to select certain main subjects and build around them. The following are examples :

1. *Our Local District* : here the museum would deal only with a local survey, and that perhaps only in terms of the present.

2. *How We Live* : a study of population distribution, occupations and human economics.

3. *Your Health* : a museum study aimed at improving health through more hygienic habits.

4. *The World's Food* : using the museum to study the world problem of hunger.

5. *Our History* : an historical survey of the district.

These are but a few of the many topics which could be used as the main theme for the museum. Many people will consider these to be very restricted—so they are, but such must be the intention where space and resources are limited. By this method the museum becomes an integral part of education in the school, an important and centralized form of visual aid, in fact it becomes a visual demonstration of the learning locked in the library.

It will be noted that the topics suggested are all concerned with the affairs of man ; this reflects what the writer considers to be an urgent need in the East, the socialization of education, a process in which the museum could play an important part:

Elsewhere in this book we have dealt with various techniques in visual aids which will be useful for setting up a museum—the making of graphs, charts, wall charts, models of various kinds and so on. Many of the things made in these ways, as visual aids, can be used in the class as well as shown in the museum. The question of display methods has been touched upon elsewhere and cannot be entered into in detail. Simplicity will have to be the keynote. Open shelving can be made easily and fairly cheaply. The trouble with it is the liability to loss and damage of specimens and exhibits. This can be overcome, to some extent, with simple methods, such as the use of cardboard display boxes with glass or cellophane tops. Glass-fronted cupboards, the ideal solution, are unfortunately extremely expensive. As many Eastern schools are frame buildings with half-walls the problems of safety and protection are accentuated. Because it seems difficult to overcome them many teachers give up the idea of trying to set up a museum. The defeatist attitude, even though it can be understood, should be deplored. It results in the loss of an opportunity for social education in responsibility. Those who have helped to build up a museum, as all children should have done, are likely to have interest in its preservation. Their attitude may well spread outwards to others who will come to share the same sense of responsibility. If the museum can be made more public, if the local people can come to see it and be encouraged to contribute to it they too will have a greater interest. By these methods the sense of ownership will lead to an increased feeling of participant responsibility.

We turn now to a short discussion of school broadcasting and its relation to visual education. Although our reference has always been to 'visual' aids the concept of 'audio-visual' aids has obviously been present—because the teacher must always talk, the need for discussion has been constantly emphasized and the sound film has been treated as the most complex and versatile of the new media of teaching. School broadcasting, though it has not had so long a history as the movement towards visualization, has made a very great contribution to education. We cannot go into the nature and value of school broadcasts here, as our purpose is merely to suggest how the two approaches, aural and visual, can be linked together to their mutual advantage.

The need for a link is shown best, perhaps, by the fact that in producing pamphlets to accompany broadcasts the habit of visual illustration was adopted early and has not only been retained, but has grown considerably. The productions of Radio Tjanst, the Schools' Broadcasting Service of Sweden, are among the best examples of this.

What can the teacher do to develop this link? The answer is obvious and short: make available as much relevant visual material as possible. From the library he can seek collateral reading material and illustrated books; in the museum there may be specimens and models related to the topic under consideration; in the classroom he has blackboard, atlas, charts and the like.

How these are to be used depends upon a variety of factors and must be decided in terms of each particular situation. One point seems clear, that a multiplicity of visual material at the wrong moment may merely detract from the value of the broadcast. During a broadcast one should use the bare minimum of visual material. It is before and after the radio lesson that it can best be used. Before the lesson it acts as orientation material, after the lesson it should be used to fill in gaps and to meet the increased interests which good broadcasting can arouse.

One of the valuable outcomes of school broadcasts has been the demonstration of the great importance of activity work. For example, a radio series on 'Our Village' may be illustrated by the local ordnance map—but to have made one's own map of one's own village is a more worthwhile experience. Many schools in England followed such a radio series by conducting a local survey and illustrating this with a model of their village. Others have turned to dramatization. The use of the dramatic method in presenting history has proved very valuable to the broadcaster—and the teacher should be quick to follow this line. The dramatic mode carries with it that sense of real experience which should be so important a part of education. Progressive teachers are making ever greater use of this, in mime, puppetry and classroom dramatization. This is an activity which should receive far greater attention in the East than it has yet done. It it true that the 'school concert' is well established as an end-of-term function—but the use of dramatics as a device in teaching has yet to develop. Until it does, teachers are neglecting to make the fullest use of one of our most important educational agents—experience.

APPENDIX

Sources of Information and Materials

In most countries information, services and materials relating to visual aids in education are available from these sources:

Commercial agents who represent the makers of visual materials and who often have libraries of films available for hire.

Prestige advertising sections of industrial and commercial concerns (e.g. oil companies) who distribute pictorial material and have films available on free-loan, or who can arrange film shows, providing apparatus, films and projectionist.

Information services attached to the foreign services of the larger nations (e.g. the United States Information Service).

Cultural organizations which are attached to a diplomatic mission, but operated autonomously; or operated (mostly in the case of smaller countries) as a subsidiary of the diplomatic mission; or as an official governmental agency of cultural type unrelated to the diplomatic mission.

The state education department of the country, state, or province, which may have a loan film library, book library, and a maintenance section for apparatus.

International organizations. U.N.O. through its specialized agencies may support services of interest to the teacher. In the case of U.N.E.S.C.O., contacts should be made with the secretariat of the national commission or with a regional office where such exists.

Universities and colleges. University departments and colleges concerned with teacher-training have libraries which usually include books on visual aids and, in some cases, even small film collections. While not usually open to the public these are often made available to the bona fide student or teacher seeking help. And for those interested in research or academic study in this field, these may be the only sources of journals and textbooks.

The keen and enthusiastic teacher will make it his business to investigate and exploit all these sources, and any others of which he becomes aware. He will find that there is usually a considerable willingness to help him, especially if he shows care in handling materials loaned to him and promptness in returning them.

HINTS ON STORAGE OF APPARATUS AND MATERIALS

Materials on loan, whether for long or short periods, need to be handled with due regard to their safety and protection from damage, just as do those belonging to the school. The following notes may therefore be useful :

Books and printed materials

The main enemies are humidity, fungal infection, attacks by insects, and damage in handling. High humidity is part of the normal environment of most regions in India and Ceylon, especially during the wet seasons. Its effects on books and printed materials can be greatly reduced, and often avoided altogether, if these are stored in cupboards and drawers provided with ventilation holes and so placed as to be in whatever air current is likely to exist. All such storage spaces should be opened frequently and their contents taken out for airing and examination. Whenever possible drawers and shelves, if made of wood, should be taken out and placed in a current of air to dry out.

It is unwise to place them in direct sunlight, which easily causes warping. Never place books in direct sunlight.

While ventilation and the use of air-holes helps to minimize the effects of humidity and the attacks of fungus, they allow access of insects to the stored materials : silver-fish, the boring beetle (bookworm), and even the ubiquitous cockroach, which has a partiality for certain glues used in book binding. To minimize these attacks ventilation holes should be covered by perforated zinc or wire-mesh. In addition to this camphor balls should be distributed throughout the cupboards.

Any book which shows attacks by bookworm or which is infested with mites should at once be removed and treated as follows :

Place the book in a large air-tight box or tin in which there is a small open bottle or tin containing a few crystals of para-di-chlor-benzene. Leave it in this for two days, remove, air for a few hours and replace it in the collection. Para-di-chlor-benzene gives off a poisonous vapour and must be handled with care and never left where pupils can get at it.

Proprietary insect repellants and insecticides are available from commercial sources and may be useful aids. They must be used with discretion, in accordance with the printed instructions and with regard to the safety of pupils.

Give particular attention to the avoidance of mechanical damage in handling books and printed materials. They should never be wrongly folded, for example. When charts are hung up for display see that pins pass through the eyelets. Avoid getting such materials wet.

Film materials

Lantern slides and miniature slides on loan are always put in a suitable box, usually with grooved sides. Ensure that the slides are handled carefully and always replaced correctly in the slots of the box. Miniature slides, mounted in cardboard without cover glasses are very susceptible to damage and must therefore be handled particularly carefully. They should always be held by the edges and nothing should be allowed to touch the slide surfaces.

Filmstrips are stored in card or tin boxes. If possible a strip of paper, 35mm wide, should be wound around the outside of the film coil, and a rubber band put round the paper. This prevents uncoiling in the tin, which often renders it difficult to take the film out without causing the coils to rub on each other and so cause scratching.

Movie film is always wound on a reel which is placed in a can. The can should be handled with care to prevent distortion, which not only makes opening and closing difficult, but may cause small gaps through which dust enters the tin. The reel (or spool) is also to be handled with care so that its sides remain parallel to each other. Avoid forcing the reel on to the projection spindle—rough action may damage both spindle and spool axle.

The film itself requires very careful handling. The first stage in this is to ensure that the projector is in proper working order and clean. The second is to ensure that the projectionist knows his job and will thread the machine properly, keep the gate clean and so on. Rough handling and the presence of grit soon breaks down the sprocket holes, causes 'tram-lines' on the film and damages the sound-track. Never allow film to uncoil and fall on the floor (as may happen if the take-up spool is not threaded correctly). If film breaks during projection *follow the instructions of the loan library*. Some lenders prefer to do their own splicing; if the user is instructed to re-splice, do this with care in a proper splicer and with minimal loss of film sequence. Rewind film after use on to its own spool.

To clean a film prepare the following *with no deviation from the formula* :

ethyl alcohol	85cc
methyl alcohol	10cc
ammonia 0.880	5cc

Moisten a piece of soft white cloth (an old often-washed cambric or linen handkerchief is excellent). Fold this into a pad, and run the film through the folds of the pad which are held between finger and thumb.

A brittle film—the result of storage in over-dry conditions —can be softened by winding it off the spool, very slowly, to form a loose coil, which is soaked for 10 minutes in :

acetic acid	5cc
vaseline	25cc
carbon tetrachloride	500cc

After soaking lift the coil out, allow it to drain, then slowly rewind through a soft cloth pad.

Films retain their condition and flexibility longer if they are waxed. The wax is applied with a soft cloth as the film is slowly wound from spool to spool. The wax is prepared from :

benzene 116 oz (3.29 litre)
carbon tetrachloride 114 oz (3.24 litre)
paraffin wax M.P. 130° F (54° C) 2½ oz (75gm)

Films should preferably be stored in 'humidor' cans which contain a felt pad on which a few drops of a suitable preservative are placed at regular intervals—say every two months. Suitable preservatives or humidifying solutions can be bought from firms concerned with cinematography.

Film cans should be stored on open shelves in as cool and dry a place as possible. The cheaper cans, being made of sheet tin, soon rust. This not only causes difficulty in opening and closing, but increases the risk of dirt getting on the film from the rust particles. Such tins should be cleared up at once and painted.

Optical elements

The optical elements of the projector and other visual apparatus need special care and attention. They are susceptible to scratching and abrasion by dust particles and to the attacks of various fungal species.

Optical elements should only be cleaned by someone familiar with the care of apparatus. Only an expert who is a very careful and methodical worker should dismount a lens to clean its various elements. All normal routine cleaning should be done by lightly brushing the external surfaces with a camel's-hair brush, a piece of lens-cleaning tissue, or a very soft, clean white cloth lightly applied. The need for such attention is reduced if lenses are covered by lens caps and the whole apparatus covered by a cloth, or better still by a plastic cover, when not in use.

Preferably the optical elements are removed from apparatus which is not in use and stored in a desiccator containing sodium silicate granules. These can be 're-covered' when charged with moisture by gentle heating.

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- Vol. VI, No. 4. *Visual Aids in Fundamental Education* (1954).
- Vol. VIII, No. 2. *Museums in Education* (1956).

In *Educational Studies and Documents*
- No. III. J. Oberwager : *How to Print Posters.*
- No. XI. H. R. Verry : *Some Methods of Printing and Reproduction.*

In *Fundamental and Adult Education*
- Vol. IX, No. 4. Six articles on visual aids in fundamental education.

RESEARCH PUBLICATIONS ON VISUAL LEARNING AND TEACHING

The number of research studies which are concerned, directly or indirectly, with visual education is now very large. No attempt is made to present even a selection of titles, not only because of the wealth of material, but because its availability to most teachers in South-East Asia is limited by library resources.

Those who wish to find out what has been done in this field should seek information in sources already named, and in the following :

Psychological Abstracts (Washington, D.C.). This is a long-established journal which gives brief reviews of research in psychology and includes sections on learning, the senses, and some aspects of teaching method.

Encyclopaedia of Educational Research. This reference book contains reviews of methods and results, some of which relate to visual methods in teaching.

In addition to such reference volumes attention should be paid to current and past issues of any of the well-known psychological and educational journals. Some of these provide index volumes which reduce the labour of searching. Examples :

The British Journal of Psychology (London).
The British Journal of Educational Psychology (London).
The British Journal of Educational Studies (London).
The Journal of Educational Research (Madison, Wis., U.S.A.).
The Journal of Educational Psychology (Baltimore, Md., U.S.A.).
The Journal of Experimental Education (Madison, Wis., U.S.A.).
Education and Psychology (New Delhi).
Vigyan Shikshak (New Delhi).

MAGAZINES DEVOTED TO VISUAL AIDS

Film User (London).
Look and Listen (London).
Visual Education (London).
Audio-Visual News (Lucknow).
Indian Documentary (Bombay).
Audio-Visual Communication Review (Washington, D.C., U.S.A.).
Audio-Visual Education (Delhi).
Audio-Visual Instruction (Delhi).

Educational Screen and Audio-Visual Guide (Chicago, Ill., U.S.A.).

Film (Sheffield, England).

Monthly Film Bulletin of the British Film Institute (London).

Perspective (London). An advanced technical quarterly review mostly concerned with apparatus and methods but also including general surveys.

Scientific Film Review (London).

Sight and Sound (London).

Teaching Tools (Los Angeles, Calif., U.S.A.).

University Film Review (New-Castle-on-Tyne, England).

Visual Aids Review (Melbourne, Australia).

BOOKS ON PHOTOGRAPHY

Teachers who become interested in visual aids frequently wish to learn something about photography. The following titles provide an adequate introduction :

S. W. Bowler : *Teach Yourself Photography* (English Universities Press, 1949).

A. J. Dalladay (ed.) : *British Journal Photographic Almanack* (Greenwood, published annually).

A. L. M. Sowerby : *Dictionary of Photography* (Iliffe, 1956).

W. D. Emanuel : *The All-in-One Camera Book* (Focal Press, 1961, 46th edition).

The Focal Encyclopaedia of Photography (Focal Press, 1961, 4th edition). An expensive but extensive desk edition costs 35s.

The first is a straightforward guide to the general elementary theory and practice of photography. The second is an annual compilation which started in 1859 and which contains a vast amount of information on every aspect of photography and its development. The third is a reference book which is particularly useful in regard to details of procedure.

ADDRESSES

Information regarding all aspects of visual education can be obtained in India by writing to: The Director, The National Institute of Audio-Visual Education, Indraprastha Estate, New Delhi.

Information regarding visual education services, materials and supplies in the United Kingdom and Commonwealth may be obtained from:

British Association for Commercial and Industrial Education (Visual Aids Section), 26a Buckingham Palace Road, London S.W.1, England.
Educational Foundation for Visual Aids, 33 Queen Anne Street, London W.1, England.
Oversea Visual Aids Centre, 31 Tavistock Square, London S.W.1, England.
Central Film Library, Wellington, New Zealand.
A.V.A. Department, University of Melbourne, Melbourne, Australia.
National Film Board of Canada, Ottawa, Canada.
The Information Officer, U.K. High Commission, New Delhi.

Information regarding all aspects of visual education in the U.S.A. may be obtained from the United States Information Service, New Delhi.

As certain materials are not readily obtainable in the smaller cities in India, and in some cases not even in the large cities, the following addresses may be useful:

Brunnings (Holborn) Ltd., 133 High Holborn, W.C.1, England (condensers, lenses, heat filters, lamp-stands, carriers for slides, focussing mounts, etc.).

Harringay Photographic Supplies Ltd, 423 Green Lanes, London N.4, England (as above).

Acton Equipment Ltd, 168 Upper Tooting Road, London S.W.17, England (as above).

E. Marshall Smith Ltd, 64 Norwich Avenue, Bournemouth, England (home assembly kits for slide projectors).

V. T. Cottle, 34a Chaplin Road, Easton, Bristol 5, England (castings for projectors and enlargers).

Edmund Scientific Co., Barrington, New Jersey, U.S.A. (all kinds of optical apparatus ; also produce complete catalogue and useful series of instruction books).

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